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# U.S. Army Evaluation of the Electronic Map Data (EMD) Prototype

John P. Bradley



December 1992

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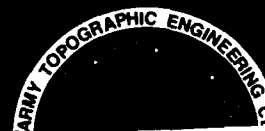
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13. ABSTRACT (Maximum 200 words)  This report provides a consolidated U.S. Army evaluation of the Electronic Map Data (EMD) prototype. This prototype was developed by the Digital Concepts and Analysis Center (DCAC) of the U.S. Army Topographic Engineering Center (USATEC). The intent of this prototype was to refine Army map background requirements by providing a real example of an alternative product. Participants in the evaluation included program managers and support contractors representing the Army components, government agencies, and private industry. Overall, evaluator comments indicated that EMD, as defined by the prototype, cannot be definitively recommended as the Army's standard map background product. Although the color separate approach does provide desirable capabilities not afforded by a composite image map, these advantages are outweighed by inherent limitations associated with decluttering by color. From user feedback indications, the original documented map background requirement submitted to DMA, which was for a product that contains declutterable feature data, requires minimal storage, and provides normalized color across map sheets, remains unchanged.				
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## **PREFACE**

This study was conducted during the spring and summer of 1991 under the supervision of Mr. Jeffrey A. Messmore, Chief, Special Studies Branch, and Mr. Francis G. Capece, Director, Digital Concepts and Analysis Center, U.S. Army Topographic Engineering Center.

The author extends special thanks to the individuals and organizations whose input assisted in production of this evaluation.

Mr. Walter E. Boge was Director, and Colonel Kenneth C. Kessler was Commander and Deputy Director of the U.S. Army Topographic Engineering Center at the time of publication of this report.

# **U.S. ARMY EVALUATION OF THE ELECTRONIC MAP DATA (EMD) PROTOTYPE**

## **INTRODUCTION**

In 1987, The Digital Concepts and Analysis Center (DCAC) of the U.S. Army Topographic Engineering Center (TEC) surveyed Army system developers to determine requirements for a digital map display product. Results of this survey indicated that the Army had an urgent need for a seamless digital map background product that provided declutterable feature classes, provided normalized color across map sheets, and required minimal data storage.

At the time of the survey, the Defense Mapping Agency (DMA) had begun development of a digital map background product which was comprised of raster-scanned composite map sheets and was called ARC Digitized Raster Graphics (ADRG). It was intended to support Navy requirements for a moving map display on board the AV-8B aircraft and to support similar requirements of the U.S. Army and the U.S. Air Force.

However, in August 1988, Headquarters, Department of the Army (HQDA) notified DMA that ADRG would not satisfy all Army digital map background requirements. Therefore, HQDA endorsed ADRG only as a short-term interim solution. Reiterating Army's requirement for a digital map background product that was declutterable by feature, HQDA notified DMA that it intended to develop an EMD prototype.

In July 1989, TEC's DCAC began preparing an EMD specification. Recognizing that the Army ideal of an EMD product comprised of scanned feature separates was not realistic at that time, DCAC pursued development of an electronic map background that was derived from raster scanning the lithographic color separates comprising composite map sheets. The intent of the EMD prototype was to refine existing Army requirements for a raster scanned electronic map background. Application display software, Level 1 Digital Terrain Elevation Data (DTED), and Interim Terrain Data (ITD) were all included in the EMD prototype package to facilitate using of the prototype and to demonstrate the capability of a digital map background product when used in conjunction with other Digital Topographic Data (DTD) products. The prototype was also intended to demonstrate and explore the advantages of declutterability, of reduced storage requirements, and of color normalization across map boundaries. To ensure compatibility, the EMD Prototype was developed to the same specifications as DMA's ADRG.

In November 1990, the EMD prototype was mastered onto CD-ROM and delivered to TEC, along with a user's manual and draft product specification. The prototype was distributed in December at a DTD Technical Exchange Meeting, hosted by TEC's DCAC. Approximately 50 representatives from the Army, government agencies, and private industry received copies of the prototype and agreed to participate in the evaluation. Also, DCAC continued to identify and to recruit additional participants through May 1991.

In June 1991, DCAC provided a preliminary evaluation to the Program Executive Officer Command and Control Systems (PEO-CCS). This report consolidated evaluation responses received from program managers and support contractors representing the following command and control

systems: the All-Source Analysis System (ASAS), the Air Defense Command and Control System (ADCCS), the Common Hardware/Software (CHS), the Operations Tactical Data Systems (OPTADS), the Army WWMCCS Information System/Command and Control System (AWIS/CCS), and the Combat Terrain Information Systems (CTIS).

The following paragraphs provide a consolidated review of all EMD comments from participants and are presented in the format specified in the EMD Prototype Evaluation Guidelines. Included are organizations represented in the June 1991 preliminary evaluation, as well as representatives of other Army components, government agencies, and private industry (see Appendix A). As might be expected, the content of each evaluation response depended on the evaluator's overall understanding of DTD. Because many evaluators did not have the necessary background to provide an in-depth technical evaluation of the prototype, they did not address all evaluation criteria.

### **DESCRIPTION OF THE EVALUATION TEST BED ENVIRONMENT**

The EMD prototype was developed for a low-end PC environment with minimum hard drive and RAM requirements. The predominant hardware/software configuration used to evaluate the prototype included an IBM or Compatible PC (usually a 386), a 40 MB or larger hard drive, 4 MB or more RAM, and a VGA or EGA color monitor with 640 x 480 or greater pixel resolution. Most configurations were equipped with a Logitech Mouse, or equivalent industry standard. Although various CD-ROM readers were used, the most common appeared to be the Hitachi 15035.

Users reported significant improvements in access and display times when reading data from the hard drive as opposed to accessing it from the CD-ROM directly. Users configured with higher levels of RAM saw additional improvements in data access rates.

### **DESCRIPTION OF TARGET SYSTEM**

The descriptions of target systems varied among evaluation participants. Consequently, the stages of development, the expected fielding dates, and the hardware/software configurations of targeted systems were quite divergent. Developers of command and control, terrain analysis, weapons, and communication systems were all represented in the evaluation.

Although identified target systems were quite divergent, one significant user community, which may total several thousand systems when fully fielded, is the various command and control systems under the umbrella of the Army Tactical Command and Control System (ATCCS) and PM-Army WWMCCS Information Systems (AWIS) with additional subordinate systems within the five Battlefield Functional Areas (BFA's). All of these systems are required to have map background functionality, and they are required to use standard map data products. Ultimately, the systems will use common hardware and a common map background software package to be supplied by PM-Common Software (CS). These will be UNIX systems employing X-Windows as a display manager and MOTIF as a graphical user interface. Resolution of display hardware ranges from 640 by 480 at the low end, to 1280 by 1024 at the high end. Peripherals will include Magneto-Optical (M-O) disk, Digital Audio Tape (DAT), and CD-ROM.

## MAJOR EVALUATION ASPECTS

**Format and File Structure.** Comments related to the data format and file structure of the EMD prototype were quite limited. Those who did comment restricted their discussions to the distribution format of the ISO 8211. There was a general consensus that ISO 8211 was acceptable, perhaps even preferred, because it provides all required information without excessive overhead or proprietary concerns and because it maintains consistency with respect to DMA products. Although the evaluators representing PM-OPTADS indicated some dissatisfaction with ISO 8211, they agreed that ISO 8211 was acceptable in order to achieve standardization.

**Data Structure.** When discussing the EMD data structure, many evaluators were confused concerning the relationship between tile size and field of view. The physical area of the displayed map on a video monitor is a product of resolution, both of the monitor itself as well as the scanning density used to compile the data. The most visible effect of tile size is the rate at which the image data is retrieved and displayed on the monitor.

Implementing a 512 by 512 pixel tile size in the prototype was intended to increase the efficiency of data retrieval. Had a smaller tile size been used, 128 by 128 pixel for example, fewer pixels would comprise a single tile, thus requiring more frequent retrieve and display iterations. For tile sizes bigger than 512, fewer tiles would have to be read, but the tiles would have to be partitioned to locate only those portions that are displayable on a given monitor. Among evaluation participants who commented, 512 by 512 pixel tiling was considered adequate.

A more recent study concerning the impacts of tile size on system performance indicated that a 128-pixel tile is probably most efficient.<sup>1</sup> However, for EMD, further validation is necessary to recommend this size.

**Compression Method.** For EMD data compression, a one-dimensional Run-Length Encoding (RLE) technique was applied. Because of EMD's binary nature (where long strings of pixels are assigned the same value), this method seemed ideally suited. When asked to comment on the RLE approach, technically knowledgeable evaluators generally agreed that it was an acceptable method. Although there were suggestions that other variants of RLE may be more efficient, there was no definitively superior alternative offered. It should be added that any deviation in the data compression approach would be transparent to the average user.

**Utility of the Prototype.** In this section, evaluators were asked to comment on the following: (1) the impact of problems and limitations inherent to a product derived from color separates, (2) the order of importance of advantages provided by EMD, (3) any data transformation that would be required to use EMD, and (4) the optimal top-down order of EMD color layers for individual operations.

Digital map backgrounds derived from scanning the lithographic color separates, as opposed to the composite map, are subject to certain unavoidable limitations. For example, on the hard copy map, features often overlap, or overprint, one another, e.g., roads may be overlapped with cities, names may be superimposed on vegetated areas, etc. As a result, when showing a particular layer, a

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<sup>1</sup>ADRG Tile Sizing Effects on Performance. Science Applications International Corporation (SAIC) Report. February 1992.



"gap" may be present that corresponds to the position of a feature on another layer. Another characteristic of color separates is that not all features appear entirely on one separate. A principal example is that of highways and improved roads, which are symbolized with brown fill and black casing. The result is that both the black and brown layers must be displayed to completely depict all roads.

The general consensus among evaluators who commented was that these limitations do not present an unworkable problem for the user. Provided that the user understands the origins of EMD, unresolved gap questions, caused by interrupted line features and polygons, can be answered by adding the appropriate layer. Although these characteristics do present definite drawbacks, these problems alone do not render EMD unusable.

As described previously, EMD provides the specific advantages of (1) decluttering color, (2) normalizing colors across map sheets, and (3) minimizing storage requirements. As part of the evaluation, the evaluators were asked to rank these advantages in order of importance.

The most important EMD advantage was reduced storage space. One bit of color per pixel not only reduces storage space requirements but also allows for larger area coverage per unit of media and increases the efficiency of data retrieval and processing. The second most important advantage was the ability to declutter. Most users recognized that EMD enables the user to declutter only by color. Although not fully meeting stated Army requirements for a truly feature declutterable product, color separability was seen to represent a reasonable compromise. The ability to normalize colors across map sheets was decidedly the least important advantage of EMD. Having color differences between composite sheets was not considered by most evaluators as a substantial problem.

In routine operations, many Army systems must transform, or reformat, DMA digital data in order to meet their particular system requirements. Evaluators were asked if any reformatting or restructuring would be required for using EMD.

Only the PM-OPTADS evaluator indicated that data transformation would be required for EMD. The Maneuver Control System (MCS), which was developed by PM-OPTADS, requires that all map background data be reformatted to the E-Map data structure and repackaged onto Hewlett Packard Cartridge tapes.

When the composite EMD image is painted onto the screen, each color layer is assigned a default position. The user then can display the layers, in any order, to best fit their particular application. To determine the optimal default arrangement of color layers, the evaluators were asked to indicate which top-down order would be most appropriate.

Responses related to the optimal order of EMD layers varied widely among evaluators. The only common response was that the vegetation layer should always be assigned to the bottom position because of its tendency to obscure other layers. However, the sequencing of other layers was not considered a critical issue. The quality of the composite image and the ability to suppress particular layers were considered the most important advantages of EMD.

**Resolution.** The scanning resolution for the EMD prototype was 100 microns (254 dots per inch) to retain commonality with ADRG. This resolution could be depicted by displaying the data at a scale of 1:1. By zooming out 2X, the resultant display represented an equivalent scanning

resolution of 200 microns (127 dots per inch). Evaluators were asked which, if either, of these resolutions would be preferred for their application.

Many user comments, while meant to address resolution of the prototype, actually addressed quality of the scanning process and/or quality of the color separates used to develop the prototype. In certain geographic areas, these additional variables resulted in blurring of small icons, bleeding together of closely spaced contours, and obtaining illegible text. When consolidating user comments on scanning resolution, responses that were relevant to actual data resolution and those that were related to the quality of the scanning process were differentiated.

Regarding data resolution, most evaluators agreed that both the 100 micron resolution and the 200 micron resolution equivalent (100 micron displayed at 2X) were satisfactory. Regarding display speed, evaluators indicated that an excessive amount of time was required to paint a tactically significant area at 100 micron resolution. Considering that the 2X display (equivalent to 200 micron resolution) was considered adequate, it can be concluded that 127 dots per inch would be a sufficient resolution, and that the resulting 4X reduction in storage and display time is worth the minimal loss in sharpness and detail.

**Media.** The EMD prototype was distributed on CD-ROM. Evaluators were asked to comment on the acceptability of this media and were also asked to indicate if, in normal operations, the data would be transferred to another media.

The unanimous response among evaluators was that although CD-ROM data transfer speeds are slow, it is an acceptable media for distribution of EMD data. Users found that by transferring the data to a hard disk, access rates could be significantly improved. None of the evaluators indicated "on line" data access requirements.

The M-O disk was suggested as a potential alternative distribution media for future EMD or for other map background products. The M-O disk is rewritable and provides a means to write, store, and transport user-generated terrain analysis products on the same media. Some evaluators suggested that the M-O disk is faster than CD-ROM and may be more conducive to combining EMD with other DTD products, such as DTED and ITD. One drawback to the M-O disk, not identified by the evaluators, is its significantly greater unit cost.

**Applications.** Most evaluators described their primary application of EMD as a map background upon which other information is displayed and as georeferencing tool that provides geographic context to battlefield information. All BFAs have requirements for terrain analysis and map display capabilities. Since EMD has very limited potential as a terrain analysis tool, most users indicated that they would prefer the data to be used in conjunction with ITD or DTED. Distribution of multiple products on a single media, or as "packages" containing a mix of data over a common area, was also preferred.

**Map Background Issues.** The Army has accepted DMA's ADRG as the standard product to support our short-term requirements for digital map background capabilities. As stated earlier, however, ADRG does not meet all Army requirements. Developing the EMD prototype was a research and development effort to determine if a product based on color separates would sufficiently meet these requirements and would warrant the inherent added cost of production. To assist TEC's DCAC in making this determination, evaluators were asked the following: (1) What was their past

experience with ADRG?, (2) Is there any requirement to compress ADRG?, and (3) If the benefits of EMD would merit its adoption as an Army map background standard?

Most EMD evaluators indicated having some experience with ADRG. Among the evaluators who commented, the primary application of ADRG has been for map displays supporting command and control or for Geographic Information Systems (GIS). The representatives of PM CTIS, the developers of the Digital Topographic Support System (DTSS), are currently using the DMA Video Disk for a map display. However, they intend to convert to a digital product.

All evaluators agreed that ADRG, in its current form, carries excessive storage requirements and must be transformed prior to implementation. For example, PM OPTADS has developed an ADRG transformation facility to meet the Maneuver Control System (MCS) requirements for digital map background. This facility compresses and repackages ADRG into a 4-bit, 127-dot-per-inch product compatible with the MCS/CHS hardware.

There was no general consensus among evaluators concerning EMD's merit for adoption as an Army standard. Some participants indicated that the decluttering benefits of EMD make the prototype more preferable than ADRG, even if a compressed form of ADRG was available. Conversely, other evaluators stated that EMD's limited capability to declutter would make compressed ADRG a better alternative. There were other comments that indicated that while a color separate product would be an acceptable interim solution prior to the availability of an actual feature declutterable product, alternative production approaches should be investigated. One example mentioned was the neural network approach, under development by the Jet Propulsion Laboratories (JPL). The neural network product is derived by programming computer processors to separate *composite map images by color*.

**Application Software.** A complete package of EMD application software was included with the prototype package. This software was intended to facilitate using of the prototype and to demonstrate the capabilities of EMD. It allowed the user to perform basic map display functionalities (pan and zoom) with additional capabilities such as gazetteer query, line-of-sight plotting, and elevation tracking. Other software features enabled the user to utilize capabilities unique to EMD. These tools enabled the user to toggle "on" and "off" layers of color, to reorder the arrangement of layers, and to assign user-defined color and color patterns.

Although some evaluators did suggest additional capabilities that would enhance the prototype's usability, there was general agreement that the application software provided sufficient support for the evaluation.

**User Recommendations.** With the objective of the EMD prototyping effort in mind, i.e. to refine Army map background requirements and to offer alternative solutions to currently available products, evaluators were asked to provide recommendations for Army and DMA regarding the future course of EMD or a similar digital map background product.

Evaluator comments reiterated user requirements for a feature declutterable, color-normalized product requiring minimal amounts of storage. While most users agreed that the capabilities provided by EMD were useful, they also recognized that the color separate approach was only a partial solution to feature decluttering. Also, the cost of EMD production would likely be high and that the availability of color separates are uncertain. It was suggested that the Army not abandon its pursuit

of a product that fully meets all documented requirements. Additional research should be conducted to determine if decluttering could be achieved through other methods.

## CONCLUSION

A primary intent of the EMD prototyping effort was to refine the Army's requirement for a digital map background. Results from the evaluation indicate that the original documented requirement remains unchanged. Just as in August 1988, when HQDA notified DMA that 24-bit ADRG did not meet Army requirements, a requirement continues for a digital product that is feature declutterable, requires minimal storage, and provides normalized color across map sheets. User feedback has also provided additional information regarding optimal resolution, compression schemes, distribution media, and data structure.

Overall, evaluator comments indicated that EMD, as defined by the prototype, cannot be definitively recommended as the Army's standard map background product. Although the color separate approach does provide desirable capabilities not afforded by ADRG, these advantages are outweighed by inherent limitations associated with decluttering by color. As an interim solution to the Army's map background requirement, the Army should pursue an acceptable compressed version of ADRG. Technologies are also evolving to separate composite ADRG by color and other technologies to properly symbolize vector data. These alternatives should be monitored as potential candidates to meet the requirements for color normalization and feature decluttering in the future.

**APPENDIX A**  
**LIST OF EVALUATORS**

1. Defense Mapping Agency.
2. PM, All-Source Analysis System (ASAS).
3. PM, Combat Service Support Control System (CSSCS).
4. PM, Air Defense Command and Control System (ADCCS).
5. PM, Common Hardware/Software (CHS).
6. PM, Field Artillery Tactical Data System (FATDS).
7. PM, Operations and Tactical Data Systems (OPTADS).
8. PM, Army WWMCCS Information System/Command and Control System (AWIS/CCS).
9. PM, Combat Terrain Information Systems (CTIS).
  - i. Digital Topographic Support System (DTSS).
  - ii. Quick Response Multicolor Printer (QRMP).
10. U.S. Army Center for Electronic Warfare/Remote Surveillance Target Acquisition (EW/RSTA).
11. U.S. Army Center for Signal Warfare.
12. U.S. Army Engineer School.
13. U.S. Army Signal School.
14. U.S. Army Air Defense Artillery School.
15. U.S. Army Combined Arms Command (CAC).
16. Developmental Sciences Corporation.
17. Jet Propulsion Laboratory.
18. Loral Defense Systems/Akron.
19. Hyperdine, Inc.
20. E-Systems, Inc.

## **APPENDIX B**

### **PARTICIPANT EVALUATIONS**

**DEFENSE MAPPING AGENCY**

## Electronic Map Data (EMD) Prototype Review

1. The following comments summarize separate EMD evaluations conducted by the DMA Systems Center. EMD evaluators were:

Dr. R. Brand  
Mr. B. Lauer  
MR. A. Noma

2. The EMD prototype was evaluated on a Compaq 386/33; 8 MB RAM; DOS Version 3.31; 600 MB hard drive; VGA graphics; Microsoft mouse; Diamond Scan monitor at 1024 X 1024 resolution; and a NEC CDR-77 CD-ROM reader at the Warrior Support Center (WSC).

3. The resolution of the EMD data is extremely poor quality. the contour lines are jagged; bleed together; and are broken-up. Lettering and symbols are not clear and difficult to read. The shading is not visually represented as viewed on the source map sheet. The color separate process fails to blend the map information. Separates overwrite other separates, depending on the display order, which can hide features. This overwrite made the map cluttered and strenuous to view. The above comments relate to a 1:1 view ratio, the image simply degrades more as the resolution is reduced by zooming out 1:2 or 1:4 times.

4. Functionally the data is extremely useful. The ability to only display certain separates, specify a color and or pattern to represent a separate and change the order of presentation for each separate provides flexibility. The fact that some features are represented on more than one separate; that one separate can contain several features thus having the same color assigned to them; and that some features have an imbedded shadow of other features can limit the true functionality of decluttering. These factors combine to produce a map image with impaired continuity. This can be either a positive or a negative attribute depending on the intended use.

4. When all the separates are displayed at one time, a map like image is presented but it is not as clean and visually acceptable as ADRG data. In striving for color normalization across map sheets, certain characteristics of a map are lost or not properly represented. These include shading or features that are generated using the half-tone screening process. Those features that display as a lighter shaded color are not blended or contiguous with the rest of the separates. This situation produces a display that is difficult to view and clutters the image.



5. Scanned separates are maintained as separate overlay files and can only be displayed as a single color; therefore the only limited colors, in the range of 6 colors, can be displayed. This approach loses the wider variation that exists on the paper map. A case in point was observed on the Ft. Hood sheet where air strips, which are dark blue on the litho, are combined with drainage, which is light blue on the litho, and shown as one color. The resulting file can only be manipulated as a single color. This consolidation of features, based on separates, can reduce recognition and increase the time required to identify features.

6. Some software artifacts were observed, such as menu ghosts, which remain on top of a view, which should be cleaned up. Also, some problems were encountered in moving between files where the software "locked up" on retrieval. It is noted that the software provided has a copyright. This appears to restrict the distribution of the software and its modification by users.

7. All GEN and OVI DDFs have format errors and are not fully conforming to ISO 8211 and should be corrected. This discrepancy was noted in using Al Brook's field program DDFFLD.

8. The following summary was provided by one reviewer:

Advantages: Reduced storage requirements with vector overlay capability.

Disadvantages: Low display resolution which equates to loss of significant information content (excessive mixed pixels at 100 micron scan resolution); 512 X 512 per tile display resolution precludes large area viewing; 16 colors are not effectively used to emulate the source map.

9. Alternatives/suggestions offered by one reviewer:

Consider a 50-micron scan yielding a somewhat larger database with considerably improved resolution.

Differentiate among the users according to need for such attributes as display resolution, speed of refresh, color fidelity to the source map, storage limitations, available RAM, etc. and tailor EMD capabilities to optimize the latter.

Consider SPOT panchromatic 10-meter image base with ITD vector overlays.

**PM, ALL SOURCE ANALYSIS SYSTEM (ASAS)**

## EMD PROTOTYPE EVALUATION

1. Summary of Evaluation Effort. The prototype evaluation was conducted on ETL provided hardware and software. The evaluation looked at the display generated by the prototype data set and its usefulness to a tactical intelligence analyst.
2. Evaluation Test Bed Environment. Hardware and software provided by ETL at their location.
3. Description of Target System(s). ASAS and Collateral Enclave systems are described in attachments 1 and 2.
4. Data structure. EMD images should also be designed to a 1280 pixel by 1024 pixel tile size for ASAS and Collateral Enclave monitors.
5. Compression Methods. No specific compression method is recommended. However, three features should be included in any selection process for a compression/decompression method. First, the algorithms must be hardware independent. Second, a compression/decompression methodology that displays the composite image within 30 seconds. Finally, consideration must be given to a storage architecture that allows for the future incorporation of parallel processing to speed up map analysis and display.
6. Utility of Prototype Data Set. The following comments are based on using the prototype EMD. They are not necessarily tied to observed features of the prototype EMD.
  - a. The default colors for the map separates must correspond as closely as possible to the colors of the lithographic paper maps.
  - b. Color separates are features desired by field users, but the speed at which the color separates are drawn must be drastically improved. A composite map must be drawn within 30 seconds. The declutter feature is particularly desirable for showing the underlying relief in forested and urban areas, and for eliminating distracting color features, such as the blue ADIZ outlines that do not have special meaning for the ground forces.
  - c. The option to draw the maps as a composite must be provided if that option will reduce the screen draw time to within 30 seconds.
  - d. More help features are needed: political boundaries and major cultural features inserted in the Overview diagram, a center point marker on the map that corresponds to the coordinates displayed in the map screen legend, and the scale of the map scale displayed on the screen.
  - e. The information boxes, such as Source Graphic, Gazetteer, etc., should not lock the mouse and keyboard.

- f. UTM coordinates must be displayed along with their corresponding geographic coordinates.
  - g. A "magnify glass" feature, in addition to the zoom, should be incorporated.
  - h. Operator feedback in the form of a thermometer that displays progress in drawing the separates is needed.
  - i. The speed of the "map pan", particularly in 4X Zoom must be increased.
  - j. The ITD is a good feature that needs to be quickly incorporated into the product.
  - k. The color layers should be drawn in the same manner as the litho process for the default, but the ability to reorder the layers should be retained.
  - l. The patterns and color palates were reasonable provided the current litho colors and application patterns are included.
7. Resolution. The 100 micron resolution was sufficient.
8. Media. CD-ROMs are an adequate medium for EMD distribution.
9. Applications. EMD would be an integral part of the Intelligence Preparation of the Battlefield (IPB) process. ITD, DTED and TTD are essential to the process and should be included with EMD. However, allowance must be made for a working file for the EMD/TTD product that would contain field supplied alterations to a local copy of the basic reference.
10. Application Software. The line of sight products are a required feature, but their speed must be increased.
11. Evaluation Documentation and Support. The User's manual was well written and any DOS user could operate the Demo without assistance. For the first time user, the manual could be enhanced with drawings that show the screen with the described features highlighted.

**PM, COMBAT SERVICE SUPPORT CONTROL SYSTEM (CSSCS)**

## Draft Memorandum

SFAE-CC-CSS-T

MEMORANDUM FOR USAETL. CEETL-CA-S (KEVIN LOGAN)

REFERENCE: EMD Prototype Evaluation

1. Two members of the CSSCS staff had attended a demo of the EMD Prototype on 9 April at ETL. Further evaluation has not occurred because CD ROM readers are not available at the PM office or the contractor's site.

2. The CSSCS map requirement will be very similar to MCS; our systems will be running on the same platforms and are required to interoperate. The MCS E-Map is regarded as the standard data set to support ATCCS map backgrounds as an interim to any future background standard. It is expected that this will be provided through CASS.

3. CSSCS must normalize color across map sheets, support decluttering, and require minimal storage. It is difficult to rank the above at this time because of the anticipated introduction of the LCU and the CHS II hardware into the ATCCS architecture.

4. POC is Paul J Howe, DSN 345-7470. Comm (703) 355-7470.

**PM, AIR DEFENSE COMMAND AND CONTROL SYSTEM (ADCCS)**



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CAS REPORT NUMBER 910264

ELECTRONIC MAP DATA  
PROTOTYPE EVALUATION (U)

7 FEBRUARY 91

"This contract was a Competitive Award"

Project Manager  
PATRIOT Project Office  
ATTN: SFAE-AD-PA-SE  
Redstone Arsenal, AL 35898-5280

"The veiws, opinions, and findings, contained in this document are those of the author(s) and should not be construed as official Department of the Army position, policy or direction, unless or designated by other documentation."

Prepared By:

*Sherri Cimino*

Sherri Cimino

Contract No.: DAAH01-90-C-0487

Classification and  
Content Approved by:

*James N. Laska*

James N. Laska

Data Item No.: A012



**ELECTRONIC MAP DATA PROTOTYPE EVALUATION**

**6 FEBRUARY 1991**

## EXECUTIVE SUMMARY

As the independent evaluator for the PATRIOT Project Office, CAS, Inc. has participated in all developmental phases of the PATRIOT Command Post Automation System (PCPAS) and thus, has considerable expertise in the area of digitized mapping requirements for HIMAD systems. The PCPAS was developed in response to direction from the Under Secretary of the Army for the PATRIOT Project Office to develop and field a Command Post Automation system to PATRIOT battalions within 6 months. Critical to the automation of Air Defense operations was the development of the PCPAS tactical planning capability, which provides the air defense planner with terrain analysis, network analysis, and site selection capabilities. These tactical planning capabilities are supported by a basemap which serves as the foundation for all tactical planner map and overlay functions. The base map is created using DMA Digital Terrain Evaluation Data (DTED) Level 1 and Digital Feature Analysis Data (DFAD). The basemap display includes evaluation contours, hydrography, vegetation, and coordinate reference lines for military grid, both 1 kilometer (km) and 10 km, and latitude /longitude reference systems.

With respect to HIMAD mapping requirements, this evaluation team has assessed the EMD prototype as functional, but requiring significant improvement. HIMAD currently has no requirement for compressed data formats to minimize storage. In the case of PCPAS, a prototype air defense automated command post system, the graphics workstation includes a 640 MB hard drive and thus minimized storage requirements have not become an issue. The workstation is supported also by a 60 MB cartridge tape drive for storing additional map data if necessary.

Selective decluttering is a mapping requirement that is quite critical to air defense operations planning, since all of the map separates are required to plan air defense deployments. Selective layering of the map separates is perhaps the greatest attribute of the EMD prototype since the ordering of the map separates varies depending on the interests of the Air Defense Planner (For example, an air defense communications planner might be most interested in vegetation to determine antenna heights, while an air defense logistics planner might be most interested in roads for supply delivery).

In reference to the application software of the EMD prototype, the map manipulation functions (i.e. zoom in/out, etc) are adequate. The evaluation team was quite impressed with the real-time update of coordinates and elevations as the user moves across the map with the mouse and with the gazetteer function which allows the user to jump to a particular city by selecting it via mouse-pick from a list of locations. Although the application

software of the EMD prototype is adequate, a list of recommended improvements has been included in the applications software section of this evaluation:

#### Evaluation Test Bed Environment

1. Organization: CAS, Inc.  
1505 The Boardwalk  
Huntsville, Al 358
2. Project/Program Name:  
  
PATRIOT Project Office /  
PATRIOT Command Post Automation System (PCPAS)
3. Relationship to Government Sponsor/Program:  
  
SETA Contractor / PATRIOT Project Office
4. Hardware/Software used for EMD Prototype Evaluation:  
Computer: Unisys Desktop 3  
DOS Version:  
Hard Disk Size: 340 MB  
Size of RAM: 20 MB  
Type of Monitor: VGA  
Resolution of Monitor:  
Type of Mouse:  
Type of CD-ROM Reader:

#### Description of Target System

1. System: PATRIOT Command Post Automation System (PCPAS)
2. State of Development:
  - First units fielded, June 1988, Ft. Bliss, TX-11 workstations
  - 41 in field today
3. System fielding date:
  - First units fielded, June 1988
  - 41 units fielded today

4. Probable date for needing EMD or similar digital map background product:

TBD

- 5 Hardware/software configuration of target system(s)

(see attached brochure)

#### Format and File structure

This evaluation team does not have enough knowledge of various formats and file structures to answer these questions.

#### Data Structure

The 512x512 tile size is not sufficient for Air Defense applications, since the text is difficult to read, even at 1:1. The resolution of the PCPAS system is 1184 x 884 which does provide an adequate display.

#### Compression Methods

This evaluation team is not familiar with a wide variety of compression techniques and thus cannot make recommendations on additional techniques. Furthermore, the need for compression methods has not surfaced in the case of PCPAS since minimal storage requirements are not as great an issue with graphics workstations as they are with PC's.

#### Utility of Prototype Data Set

1. Gaps appearing in the color separates would not affect automated air defense operations. However, Air Defense planners would be most likely to use the separates in combination rather than one at a time.
2. The fact that not all features appear entirely on one color separate would not impact Air Defense operations since map sheets would most likely be used in combination, as mentioned above.
3. Order of importance:
  - a. Decluttering by color separates
  - b. Color normalization across mapsheets

c. Minimization of storage requirements

4. EMD would need to be reformatted for the INTERPRO 340
  - Unix
  - Fortran or C Source Code
  - Hooks to machine language
5. EMD would be useful to Air Defense planners only if the capability to display the layers in any order is retained. The ordering of the color separates is dependent upon the Air Defense planner. Vegetation might be most critical to a communications planner; roads might be most critical to logistics planners; high points might be most critical to operations planners, etc.
6. Prior to occupying an area, Air Defense planners conduct a detailed analysis of the terrain to determine whether or not it can be occupied by the weapon system. Analysis of this type requires map data that very accurately represents all terrain characteristics. Because of this requirement for very accurate terrain representations, a compressed form of ADRG such as EMD will not be useful to Air Defense Planners. This evaluation team felt that paper maps still would be required with the EMD prototype since the resolution is insufficient to determine exact locations, which defeats the purpose of an automated mapping tool. Air Defense planners would prefer to load map data for each particular Area of Interest (AOI) in order to have a digitized map background that accurately represents the paper maps.
7. In the opinion of this evaluation team, a product like EMD is not a requirement for HIMAD Air Defense operations. Thus, we would not expect that a project office such as PATRIOT would fund the production of such a product.

**Resolution:**

The resolution of the EMD prototype, even at 1:1, is insufficient for Air Defense applications since the text at 1:1 is difficult to read.

**Media:**

The CD-ROM is an acceptable distribution medium for the EMD. The system with which this evaluation team is familiar (PCPAS) would require that the EMD be loaded onto a 60 Mb cartridge tape. CD players were not available two years ago when the PCPAS

hardware was selected. However, they will be a near term system upgrade.

#### **Applications:**

1. EMD or a similar map background would serve as a digital map background for battle management and force operations. Specific required applications have been provided in the applications software section of this evaluation.
2. This evaluation team does not foresee a requirement for EMD.
3. Air defense applications would require a product such as EMD to be useable in a night environment, most likely in shelters with low lighting.

#### **Map Background Issues**

This evaluation team does not have enough knowledge of ADRG to address these questions.

#### **Applications Software**

Two applications software features with which the evaluation team was most impressed were the following:

1. The real time update of coordinates and elevation as the cursor is moved across the screen is perhaps the most important feature of the applications software. (Comment: for air defense applications, the coordinate conversions should include Georef also).
2. The Gazetteer feature which allows the user to select a city via mouse-pick and jump to a particular location on the map is helpful.

As a minimum, the applications software must support the following air defense applications:

#### **Mapping:**

- Must provide the following types of map backgrounds:
  - Raster scanned maps for actual data
  - Color-coded elevation maps which allow the user to interactively identify terrain which meets selectable elevation/slope criteria

- DMA Digital Features Analysis Data (DFAD) overlays
- Shaded relief maps generated from DTED to be used for terrain visualization
- Maps must be consistent with the following formats defined in FM 100-5-1:
  - 1:50,000 topographic line map
  - 1:100,000 topographic line map
  - 1:250,000 scale JOG
  - 1:1,000,000 scale ONC
- Must support the following view control functions:
  - Zoom-in
  - Zoom-out
  - Pan (roam)
  - Window area
  - Coordinate conversion: LAT/LONG, Military Grid, GEOREF, UTM
  - Map data thinning (declutter)
  - Screen copy
  - Scaled plot (including overlays)
    - 1:500,000
    - 1:250,000
    - 1:100,000
    - 1:50,000
- Must support overlay of grid lines:
  - LAT/LONG grid
  - Military grid (10k)
  - Military grid (1k)

#### **Communications Planning:**

- Must support analysis of an entire network (multiple links) as well as single link analysis
- Must support archival/retrieval of multiple link network
- Must allow user to add, move, or delete communication site placements by mouse pick or coordinate key-in
- Must allow user to specify antenna heights and frequencies
- Must display communications intervisibility plots, terrain impacts, terrain cross-section, antenna heights, frequency designations, and Fresnel zone impacts

- Must calculate and display earth curvature and normal atmospheric refraction by using the 4/3 earth curvature model
- Must indicate optimum locations for necessary relays after sites have been placed within the network and evaluate communication network performance
- Capability to store and display LOS for multiple networks as well as for individual sites within each network.
- Capability to add, move, delete, or modify (antenna height) for all sites within a network.
- Capability to analyze and display LOS for all links in a network based on terrain elevation, Fresnel zone calculations, frequencies, and antenna heights.
- Capability to view the terrain cross section between two communications sites with Fresnel zone impacts, terrain impacts, antenna heights, UTM coordinates, and link ID included as part of the sideview display.
- Capability for the computer to generate the network automatically and place necessary CRG's, given unit locations and frequency requirements.
- Capability to generate a communications bubble diagram which shows connectivity between communications nodes, identifies the nodes, and gives frequency, link polarity, azimuths, and back azimuths in a graphic format currently used by Air Defense.

#### **Tactical Overlays:**

- Must provide the user with the capability to generate and edit military overlays using standard symbology as defined in FM 101-5-1, Operational Terms and Symbols, for use in describing either current or planned, enemy or friendly ground force dispositions
- Must allow the user to place symbols on the basemap using either the mouse or precision coordinate key-ins.
- Must provide the user with the capability to create, manipulate, and label symbology describing:
  - Units



- Headquarters
- Installations
- Observation posts
- Points
- Lines
- Areas
- Routes

#### Defense Design:

- Must allow the user to analyze, store, and retrieve radar sector coverage for up to 40 radars and distinctly display the analysis results as an overlay to the basemap
- Must allow the user to toggle between menu options that support concurrent tasks within the decision-making process (thus, site locator and defense plan options must be integrated)
- Must analyze radar coverages using a terrain elevation file derived from DTED Level 1. Analysis must account for earth curvature and normal atmospheric refraction using the 4/3 earth curvature radius model.
- Must display analysis results for at least four floor elevations referenced to ground level, showing areas where each radar provides coverage. Floor levels must be selectable by the operator.
- Must allow user to add, move, or delete radar placements using either mouse or precision coordinate key-in.
- Must allow user to store at least 40 sites in a deployment.
- Menu option for storing a collection of sites as a deployment must reside on radar sector coverage menu for easy storage, retrieval, and manipulation of sites.
- Must allow user to place/modify Primary Target Lines (PTLs) using mouse or precision azimuth key-in.
- Must be integrated with a database, allowing user to store and update both radar parameters and deployment information for recall and reanalysis at some future time.
- Must allow user to toggle the display of radar coverage effects of any or all radars, allowing the user to assess the impact of the movement or loss of one or more sites.
- Must provide the user with assistance in site selection.

#### Operations:

- Automate manual reporting methods (CONUS and NATO)
- Provide for enemy overlay generation/transmission.
- Maintain accurate reporting methods for the following:
  - Friendly locations
  - PATRIOT system equipment status

- Weapons control status
- SAMSTATREPs
- Provide FDC interface for ACO processing/dissemination.
- Automatically generate/transmit ACO overlays as they are received and alert user when they become active.
- Provide for friendly overlay generation/transmission.
- Interface with Maneuver Control System (MCS) to provide ground forces overlay.

#### NBC:

- Automate manual NBC reporting process
- Automatically perform required calculations based upon information received
- Automatically generate NBC overlays based upon information received

#### Recommendations

DMA Mapping Products currently available have proven to be adequate for the system with which this evaluation team is most familiar (PCPAS). No requirements for compressed data structures have surfaced. The only recommendation to DMA would be to accelerate the development of TTD.

#### Evaluation Documentation and Support

All evaluation documentation and support provided with the EMD prototype were excellent.

**PM, COMMON HARDWARE/SOFTWARE (CHS)**

## **EMD Prototype Evaluation**

### **Executive Summary**

The Electronic Map Data (EMD) prototype was evaluated as being superior to ARC Digitized Raster Graphics-based products in supporting Army Tactical Command and Control System (ATCCS) requirements. The ISO 8211 format of the data is preferred over the alternatives. The largest problem with the data is its 100 micron scan resolution; 200 micron resolution is preferred. Consideration should also be given to production of an additional data set at 400 microns to support substantially improved performance in situation display applications.

### **Evaluation Test Bed Environment**

Please note that the evaluation package was not received at TRW until April 15, 1991, which allowed only a limited time to perform the evaluation. Many of the comments provided in this evaluation are based on prior knowledge and review of the EMD program and data format specification. This knowledge was developed through Maneuver Control System (MCS) System Engineering & Integration (SE&I) efforts relating to MCS E-Map requirements and data transformation. During these efforts in-depth analyses of both requirements and data formatting issues were performed.

### **Project/Program:**

This evaluation performed by Common ATCCS Support Software (CASS) Project, Systems Engineering and Development Division, TRW, Carson, CA for PM Common Software.

### **Point of Contact:**

Mr. Rob Thomas  
TRW SEDD, DH2/1792  
18901 South Wilmington Ave.  
Carson, CA 90746

Tel. 213/764-3806

### **Hardware/Software Used for Evaluation:**

Computer: Hewlett-Packard Vectra QS/16S (386)

DOS Version: 4.01

CD-ROM: IIP

Disk: 80 MB

RAM: 4 MB

Monitor Resolution: 640x480 (VGA)

Mouse: IIP (2 button)

#### **Target System(s) Description**

The target systems for this product are the various command and control systems under the umbrella of the Army Tactical Command and Control System (ATCCS) and PM-Army W<sup>3</sup>MCS Information Systems (AWIS), including MCS, AFATDS, FAAD C2I, ASAS, CSSCS, UTACCS, and AWIS. Additionally, various subordinate systems within the five Battlefield Functional Areas (BFA) include map background functional requirements and are required to use "standard" map data products. Ultimately, these systems will employ a common map background software package to be supplied by PM Common Software. The C2 systems are all in various stages of development and fielding. Requirements for a common map background software package have been developed. Software reuse evaluations are underway to support a software delivery scheduled for March, 1992.

Applications for the raster map product include use in Situation Map displays and as backgrounds for the display of terrain analysis products. "3-D views" will also be created from the data.

Target system hardware and software includes MCS NDI, CHS I, and CHS II. These are UNIX systems with X-Windows and MOTIF. Display hardware ranges from VGA (640 x 480) to high-resolution (1280 x 1024). Peripherals available include M-O (re-writeable) disk, Digital Audio Tape (DAT), and CD-ROM. However M-O disk and DAT are expected to be more prevalent than CD-ROM in fielded system configurations.

#### **Major Evaluation Aspects**

##### **Format and File Structure**

1. In general, the format and file structure was found to be acceptable.
2. Opening a discussion of whether ISO 8211 is an appropriate standard for use as a distribution format is like opening a can of worms - it can get really ugly as many developers and programs have their own, in some cases proprietary, formats.

Alternative formats were investigated for the MCS SE&I program and the ISO 8211 format was found to provide all required information without excessive overhead. In fact, the structure/organization of the format was not significantly different than the distribution format used by another program and only a moderate amount of software modification would have been required to use ISO 8211 as a distribution format.

However, most programmers experience quite a shock when they first see the ISO standard since it appears to be more complex than it needs to be. This creates quite an initial resistance to the format (to say the least!) In the MCS experience, the resistance was seen to decrease over time, to the point where ISO 8211 would actually have been preferred by those programmers who spent the time to actually understand the format and evaluate the issues.

Overall, the ISO 8211 format is believed to be acceptable as a data distribution format. It is, in fact, preferred as a solution because it resolves the inevitable arguments over "proprietary" formats.

3. We would like to see "insets" handled as separate images rather than as part of the original source image. Note that the DMA stated in mid-1990 that ADRC would treat insets as separate Distribution Rectangles. (Mr. R. Joy, of USAETL, can provide more information on the DMA statement.) We would like to see that approach continued.

End-system requirements include continuous display of the geographic coordinates of the cursor location as the cursor is moved about the display. An unnecessary performance hit is incurred if the end-system must also determine whether the cursor is in an inset so that coordinates can be calculated correctly.

### Data Structure

A smaller tile size would appear to be more efficient. The prototype data set and software should have included a sample of data in smaller tile sizes to support evaluation of performance effects.

### Compression Methods

Run-length statistics should be evaluated in some detail across a sampling of maps to determine whether a shorter (7-bit) run-length encoding should be used to decrease overall file size. In trivial cases analysis shows that the 15-bits of run-length produces reasonable results. However, in "busy" maps, such as in the samples provided, a shorter run-length might be much more efficient.

### Utility of the Prototype Data Set

1. It's likely that the users of the various C2 systems supported by Common ATCCS Support Software will have conflicting views on which layers are most important to them. However, the EMD color separates format allows software capabilities to be implemented which can re-order the various layers to user preferences, if required.

It appears that re-ordering of the layers can be very dangerous. For example, hydrology features can be hidden vegetation. It may prove necessary for the end-system to enforce the ordering used in the paper map production process while retaining the ability to enable/disable each layer.

The idea of combining separate layers having the same color has some merit because it will improve overall performance. The elevation tint layers are good candidates for combination.

2. Minimization of storage requirements is extremely important, primarily because data throughput to peripherals is relatively limited and the less data that needs to be moved, the better. Decluttering by separates and color normalization capabilities are also requirements, but they're inherently supported by the color separates format.

3. In routine operations EMD will, undoubtedly, be reformatted. For UNIX/X-Windows systems the likely internal format is an X-bitmap, but that isn't absolutely required.

The wide range of hardware platforms appearing on the battlefield means that the data will be reformatted. Even in the higher end (not the highest end) systems supporting 8-bit color (and text overlays in some cases) only 4-bit planes may be available for loading map data because the other planes are required for overlay data. FAAD C2I, for example, handles map backgrounds that way for performance reasons. Fortunately, the separates format allows for relatively straight forward reformatting "on-the-fly", without requiring a transformation facility or specialized operator training.

### Resolution

The 100 micron scan resolution is the single biggest problem with the prototype data set, as evidenced by the gray hairs which grew while waiting for the prototype software to paint a tactically significant geographic area at 4X zoom-out.

200 microns provides adequate clarity and is very much preferred for performance reasons. In fact, consideration should be given to providing data sets at both 200 and 400 microns, at a minimum in separate volumes, if not on the same volume.

The adequacy of a 200 micron scan resolution was established by CACDA during the development of the MCS E-Map data format when they conducted a survey at the Command and General Staff College. Additional user feedback on the resolution should be sought now that MCS has a product in actual user hands.

Some reviewers might argue that the 100 micron resolution supports detailed terrain analysis - but that's what vector and elevation data is for, right?

Typically, a situation map display must show a much wider area than is visible at 1:1 zoom using the 100 micron data. The recommendation to include an additional data set at an equivalent of 400 micron resolution supports improved display response times when viewing these wider areas. Viewing the 200 micron data at 2X zoom-out involves manipulating four times as much data as displaying 400 micron data at 1:1. The performance impact is dramatic. Production of the 400 micron data set does not require additional scanning steps as a pixel elimination process performed by computer should be adequate.

### Media

In normal operations the data will be copied onto another media, and possibly reformatted in the process. Target media include Magneto-Optic (re-writeable) disk, DAT, hard-disk, and probably, in the future, a 3.5" format optical disk (floppy-optical, or "floptical" disk).

Performance is a significant driver - particularly since the CD-ROM is sooooo slow! The re-writeable optical disk also provides a means to write, store and transport user generated terrain analysis products.

### Applications

1. Distribution of data in "packages" containing a mix of data is preferred. Common to all BFAs are requirements for terrain analysis and situation map displays. Packages should contain a mix of map scales, elevation data, and Interim Terrain Data. Two series of products should be considered: first, a series containing large scale maps (1:50,000 and 1:250,000), ITD, and elevation data; second, a series containing smaller scale maps (1:250,000 and smaller) and elevation data (no ITD). The first series supports tactical analysts, while the second series supports situation displays and coarse analysis at higher echelons.

2. Regarding the "night environment" question: most display technologies are luminous and don't rely on ambient light - therefore "red-light" readable isn't really an issue. End-user hardware and software is responsible for assigning colors and intensities to each of the separate layers.

### Map Background Issues

Extensive knowledge of the ADRG product was developed by the evaluators during the MCS E-Map effort. That program is transforming ADRG data to 4-bits (16 colors) and 200 micron (equivalent) resolution.

EMD is preferred over the composite products, even if compressed forms of ADRG become available. Among other things, the user community has stated a requirement that end-user systems be able to print hardcopy maps at original scale and projection. Since ADRG-based products are in the ARC projection (as is EMD) the data must be "rubber-sheeted" before printing. Rubber-sheeting composite products is much harder than rubber-sheeting the separates product.

The EMD separates are transformable into a format acceptable by virtually any hardware platform (monochrome, 4-bit, 8-bit, etc.). The same is not true of ADRG-based products, even if compressed.

Overall, EMD supports a much wider variety of users than ADRG or ADRG-based products.

#### Applications Software

ATCCS "map" requirements are well documented (as USAETL is well aware).

Evaluation of data format issues would be better supported in the future if alternative data sets and corresponding software are provided. For example, the scan resolution and tile-size issues were anticipated in advance, the prototype could have provided demonstrations of the alternatives.

Source code should be provided, where possible, to support evaluation of formatting issues and questions, such as the question about ISO 8211 formatting.

#### Recommendations

EMD is strongly preferred over ADRG-based products for raster-map applications within ATCCS. Issues requiring further evaluation before the product is developed as a standard include scan resolution, the appropriate length for run-length encoding, and how products should be organized into packages.



## EVALUATION OF THE EMD PROTOTYPE

These comment are in direct response to the DCAC individuals questionnaires (see attachment)

Evaluation test bed environment: POC for this evaluation is George Colvin, OPM Common Hardware/Software (CHS), SFAE-CC-CHS, Fort Monmouth NJ 07703-5000, DSN 995-4041. The evaluation was performed by David Bui, (908) 532-1359, DSN 992-1359.

1. The evaluation test bed environment consists of:

HP Vectra ES/12, 286/12MHz  
DOS Version 3.2  
40 MBytes hard disk  
4 MBytes of RAM  
Enhanced Graphics Adapter (EGA) monitor, 640X350  
HP mouse  
Hitachi CD-ROM model CDR-1503S

2. Description of target system(s): At the present time, CHS does not have any requirements for EMD. If EMD is to be used the target systems will be the Transportable Computer Unit (TCU) or Portable Computer Unit (PCU).

- . Stage of development: Nondevelopmental Item
- . System fielding date: Available now
- . Configuration of target system:

Hardware: 32 bit Micro-processor  
12 MIPS  
16 MByte RAM (TCU)  
Graphics coprocessor  
200 MByte hard disk  
RS-232, SCSI, LAN interfaces, IEEE-488  
trackball  
16" color monitor  
Software: POSIX and MS-DOS capability  
X Window  
Ada, C compilers  
Word processing and spread sheet

3. Format and File Structure: No problems encountered in the utilization of ISO 8211 for EMD prototype.

4. Data structure: CHS does not have any EMD application; therefore we do not recommend any other different tile size. However, the speed of display of the EMD prototype is slow. It will be much easier for the users to make such tradeoff decision if a well determined relationship between tile size and display speed is established.

5. Compression methods: There is no other recommended

compression techniques.

6. Utility of prototype data set: Although map features often overlap, or overprint one another, EMD prototype provides the function of raising or lowering a layer. This is one way of limiting the side effect of overlap or overprint. To compensate for these effects, the user can display the most important layer last, and he may turn off other insignificant layers.

7. Resolution: At 1:1 ratio, some of the display is very hard to read compared to the paper maps. In order to be able to read all text, zoom-in function has to be used.

8. Media: CD-ROM is the appropriate media for this type of application. Speed is improved significantly if data is loaded on hard disk, but it will require very large disk capacity.

9. Application: There is no intended uses of EMD or similar digital map background product for Common Hardware/Software.

10. Map background issues: Arc Digitized Raster Graphics (ADRG) consumes too much disk space and has distract colors. It is certainly beneficial to adopt EMD as a map background standard.

11. Applications software: The most important feature of EMD prototype is the capability of displaying selected layer(s) for specific application.

12. Recommendations: An attempt to run the prototype on an HP-370 (target system) utilizing the DOS coprocessor was unsuccessful. In order for the EMD product to be useful to the CHS product set, the EMD product must be targeted for the POSIX environment.

**PM, FIELD ARTILLERY TACTICAL DATA SYSTEMS (FATDS)**

SFAE-CC-FS-A (SFAE-CC-SEO/14 Mar 91) (70-17b) 1st End N. Keselowsky/  
jg/20336  
SUBJECT: Electronic Map Data (EMD) Prototype Evaluation

Project Manager, Field Artillery Tactical Data Systems, ATTN: SFAE-CC-FS-A  
Fort Monmouth, NJ 07703-5404 31 MAY 1991

FOR Commander, U.S. Army Engineer Topographic Laboratories, ATTN: CEETL-CA-S  
Fort Belvoir, VA 22060-5546

1. As requested, the following information is provided:

a. Hardware used:

- (1) Zenith 248 (80286) based running at 8MHz)
- (2) 20 MByte hard disk
- (3) 640K RAM with 512K extended
- (4) EGA monitor
- (5) 0.31mm dot pitch (640 x 480)
- (6) Logitech mouse
- (7) CD-ROM reader: Hitachi CDR-1503S

b. Format and File Structure. N/A

c. Data Structure. N/A

d. Compression methods: due to the slow access time for CD-ROMs, a study should be done comparing the existing compression method to modifications in Hoffman coding. Hoffman coding takes longer to encode but results in smaller files. Since the machines are considerably faster than the CD-ROM, the decompression of the map data using this scheme may result in a time savings over RLE.

e. Utility of Prototype Data Set N/A

f. Resolution. N/A

g. Media: CD-ROMs are acceptable, however, the current CD-ROM readers are too slow to effectively transfer the data in a real time environment. The data should be transferred to disk to increase running efficiency. Of course a very large hard disk would be required. A hardware compression board would ease the storage resource burden.

h. Applications N/A

SFAE-CC-FS-A

SUBJECT: Electronic Map Data (EMD) Prototype Evaluation

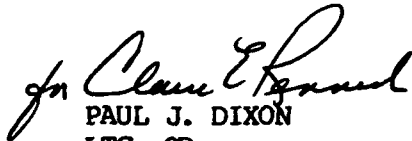
i. Major Background Issues N/A

j. Applications Software N/A

k. Recommendations: Your office should contact other software developers involved with using digitized data (e.g. RMS Technologies, Inc., 5 Ever Drive, Marlton, NJ 08053) for a demo of their mapping applications. The overall evaluation of EMD Prototype is that although it is somewhat better, the usefulness does not add enough value to pursue. Further, decluttering by eliminating one color sometimes removed the wanted feature thereby limiting usefulness.

1. Evaluation Documentation and Support: The instructions for setting up the CD-ROM reader was incorrect and took many tries at setting the interrupts on the SCSI board until the drivers and software were working.

2. The POC in this office is Mr. Nicholas Keselowsky, DSN 992-0336, commercial (908) 532-0336.

  
PAUL J. DIXON  
LTC, OD  
Product Manager, AFATDS

CF:

PEO CCS, ATTN: SFAE-CC-SEO (J. Derco)

**PM, OPERATIONS TACTICAL DATA SYSTEMS (OPTADS)**

## EVALUATION REPORT

### Executive Summary

The evaluation of the Electronic Map Data (EMD) prototype performed by the Office of the Program Manager, Operations Tactical Data Systems (PM OPTADS) consisted of viewing the prototype data and manipulating the data using the man-machine interface provided by the Engineer Topographic Laboratories.

### Evaluation Test Bed Environment

Organization: Office of the Program Manager, Operations  
Tactical Data Systems, Systems Engineering Office

Project Name: Maneuver Control System

Point of Contact: Ms. Denise Giovanniello

Address: U. S. Army CECOM  
ATTN: SFAE-CC-MVR-TM  
Fort Monmouth, NJ 07703

### Hardware/Software Environment:

Zenith 248  
MS-DOS 3.21  
Disk - 20 MB  
RAM - 640kB  
Monitor - EGA  
Mouse - Logitech  
CD Reader - Hitachi CDR 1503S

The low-end PC environment is representative of the PC environment at PM OPTADS. However, a CD ROM reader is not a standard peripheral.

### Description of Target System

The Maneuver Control System (MCS) is developed in an evolutionary manner. A production decision for the Non-Developmental Item hardware was given in November 1985. The system is currently being fielded with MCS Version 10.03.1G software and upgraded with Hewlett Packard 375 processors. MCS 10.03.1G software provides an electronic map background display based on Arc-Digitized Raster Graphics. Tactical symbology is displayed as an overlay based on information stored in the MCS relational database.

PM OPTADS is also responsible for the E-Map prototype development. This development is performed in parallel with MCS software in order to refine requirements and capabilities without interfering with the MCS program. Currently, terrain analysis and terrain visualization capabilities as well as software performance enhancements are the focal points of the prototyping effort. The results of this prototyping effort will provide alternatives for future MCS software capabilities.

#### Maneuver Control System Hardware/Software Platform

##### MCS Segment 10 and Segment 11 Hardware Baseline:

- Hewlett Packard 375 Processor
- DOS Co-Processor
- 8-16 MB RAM
- 15 or 16 Inch High Resolution Display
  - 1024x768 Pixel Resolution
  - 6 Bit Planes for Color
- 5 1/4 or 3 1/2 Inch Floppy Disk
- 152-200 MB
- HP 67 MB Cartridge Tape
- Hewlett Packard Trackball
- Thinkjet Printer
- Hewlett Packard thinLAN
- Programmable Communications Interface Unit
- Power Converter/Uninterrupted Power Supply

##### MCS Version 10.03.1G software includes:

- MS-DOS Version 3.3
- Unix Version 7.0
- Uniplex II+ Version 7.00b



## Major Evaluation Aspects

**Format and File Structure:** A file format other than ISO 8211 may better lend itself as a distribution format. However, the Defense Mapping Agency has already committed itself to the implementation of ISO 8211 in ADRG. In anticipation of direct use of DMA products, MCS through the E-Map prototype is also making the "ISO 8211 commitment". Following the current standard will facilitate the direct utilization of DMA products.

**Tile Size:** Based on MCS experience, tiles are significant only when run-length encoding is used. Tiles are not part of the MCS E-Map prototype data structure.

**Utility of Prototype Data Set:** The MCS map display requirements call for a digital product which looks like a paper map. The gaps which appear in decluttered displays can be misleading to the user, i. e. a road appears to be disjoint.

It is understood that EMD is not a true feature separate capability, but a pseudo-feature separate capability via color separates. The MCS user (i. e. Combined Arms Combat Development Activity) would be responsible for commenting on the utility of color separates versus feature separates.

Priority ranking of data characteristics from a materiel developer perspective would be:

1. color normalization across map sheets
2. minimization of storage requirements
3. decluttering by color separates.

In order to use EMD in MCS 10.03.1G or MCS Segment 11, without impacting the software baseline, the data would have to be reformatted to the E-Map data structure and repackaged on Hewlett Packard cartridge tapes. In addition, if a data set with color declutterability was introduced, software should also be integrated to take advantage of this characteristic.

**Resolution:** The 100 micron resolution was acceptable. All text was legible.

**Media:** CD ROM is an acceptable media for data distribution, however, currently fielded systems do not have CD ROM drives. CD ROM is highly preferable over 9-track tapes.

Due to CD ROM access time - 25 times slower than Winchester Disk - it will be necessary to load digital topographic data from CD ROM to disk, assuming that the system has a CD ROM reader.

**Applications:** Digital map background data is used to give geographic context to tactical symbology and terrain analysis product graphic overlays.

The optimal distribution content for a single CD ROM would include: digital map background data, DTED, and ITD - assuming a system has been developed to take advantage of all three data sets. This would improve performance since the data would all be accessed from a single source.

#### Map Background Issues

MCS has requirements for Segment 10 software to provide a map background display which will support the display of the graphic overlay using standard Defense Mapping Agency digital products. In order to meet this requirement PM OPTADS has developed a transformation system which compresses and repackages ADRG to a format compatible with MCS Non-Developmental Item and Common Hardware systems.

The E-Map ADRG compression consists of spatial compression (eliminating alternate pixels) from 254 to 127 dots per inch and color compression using a shortest distance algorithm to reduce color representation from 24 to 4 bit color.

After compression the data is archived on re-writable optical disk. The required maps are then packaged on Hewlett Packard tapes according to their geographic locations in a predefined structure. The two structures which are currently required are Tactical and Operational E-Map Tapes. A Tactical Tape consists of a one degree square area of 1:50,000 scale Topographic Line Maps plus an overview 1:250,000 scale Joint Operations Graphic (JOG). The Operational Tape consists of a four degree square area of 1:250,000 scale JOGs.

When DMA production of 4-bit ADRG begins, this data will be reformatted to simulate E-Map data and repackaged on cartridge tapes (or the current Army Tactical Command and Control System distribution media) for use with MCS.

MCS has requirements for feature decluttering. The implementation of a color separate product would be an interim until a "feature separate" database is available.

PM OPTADS does not have funds available for database development.

## Recommendations

EMD is one alternative for the interim until DMA produces the required coverage of a feature declutterable database. EMD production costs, EMD production schedule, and end-user system development and integration cost impacts must be analyzed in order to make a recommendation.

Without a program plan with cost and schedule for EMD production, it can only be estimated that since EMD production must be very costly when compared to ADRG production. This is apparent since EMD requires scanning individual paper map separates for each map sheet.

Based on available resources for EMD production, full coverage of EMD would not be expected for several years.

Systems like the MCS would have to enhance current software capabilities to include EMD manipulation. Software development would also be required for the transformation and repackaging of EMD to provide compatibility with MCS hardware and software.

The value added of EMD over compressed ADRG (E-Map) does not outweigh EMD development, production, and integration costs. It is recommended that other alternatives to EMD production are researched. One possibility is color decluttering based on compressed ADRG at an end-user system level.

**PM, ARMY WWMCCS INFORMATION/COMMAND AND  
CONTROL SYSTEM (AWIS/CCS)**

## EMD PROTOTYPE EVALUATION

**EXECUTIVE SUMMARY:** I visited the evaluation effort POC at ETL and spent approximately two hours "exercising" the prototype. After coordinating the required submission date with Mr. Logan on 19 Apr 91, I made a return visit on 22 Apr 91 for the same purpose. My following comments are based on that experience and my review of the associated documentation.

### EVALUATION TEST BED ENVIRONMENT

John Parkinson, Computer Specialist, GS-334-13  
AWIS PMO  
SFAE-CC-AWT-E  
Stop C-35  
Fort Belvoir, VA 22060-5456  
(703) 355-7158 or AV 345-7158

**Hardware/Software Used:** I used the ETL workstation which had the prototype already loaded.

### DESCRIPTION OF TARGET SYSTEMS

**AWIS Product Lines (Strategic (Echelons Above Corps) Army Command and Control System - SACCS) Software:** We are currently planning to use the DeLorme resource that is being planned for the JOPES systems.

**Standard Army Theater Command and Control System (STACCS - AKA UTACCS):** This system is currently using a system called SITMAP for its map graphics requirements.

### MAJOR EVALUATION ASPECTS

**Format and File Structure:** Unable to evaluate at this time.

**Data Structure:** Unable to evaluate at this time.

**Compression Methods:** Unable to evaluate at this time.

#### Utility of Prototype Data Set:

The overlap of features is indeed a problem. Each "layer" should be capable of being displayed alone in its entirety. Which takes precedence would then be decided by the order of precedence assigned by the user. Until this problem is resolved, the utility of the decluttering feature is seriously compromised.

The road features should be one separate color from cultural/urban layers. I would want to be able to view the roads portrayed in the black sector without the additional cultural information. In highly urbanized areas such as Germany, having urban depictions the same color as roads makes it difficult to trace road nets.

Resolution: I was personally satisfied with the resolution provided. I cannot, however, comment on whether it would satisfy the AWIS/UTACCS users in the field. They would need to be tasked to evaluate this product as well.

Media: I was satisfied with CD-ROM.

Applications: At present, AWIS is committed to using the DeLorme product that is also being utilized by JOPES. UTACCS is currently using SITMAP. No near term use for EMD is currently foreseen for either the AWIS or STACCS (UTACCS) systems.

Map Background Issues: I have had no personal previous experience with ARDG and am therefore unable to answer these questions myself. Since AWIS is currently committed to using the Joint standard, it would probably not support production of EMD. If EMD is adopted by the tactical C2 systems (ATCCS), the requirement for UTACCS-ATCCS interface might require a limited adaptation of EMD.

Applications Software: Unable to evaluate at this time.

#### Recommendations:

a. I felt that the road network graphics contain too much clutter since they also include the urban areas with that color. It may help to separately scan the urban area representation in order to reduce the clutter.

b. Not all of the menu options worked: Source Graphics as they apply to legends, LOS legend did not work on my first visit. The second time it did but was quite slow. Moving from one sector of the display to another was quite time consuming. Keeping this option should be carefully scrutinized.

c. An option for map clear should be added to the main menu.

d. I found the gazetteer option to be highly useful.

e. The compatibility of EMD with overlays/map graphics symbols, military symbols and related software is critical. A listing of current products and a demonstration of how they run on EMD would be most helpful.

f. Standardization of Army map symbols is a must and should be accounted for in the AR 25-9 (Data Management) Program.

g. The current decluttering capability still has its problems with respect to layer overlap. However, even with that limitation, decluttering increases the utility of the map graphics and should be seriously considered for adoption in any fielded system.

#### EVALUATION DOCUMENTATION AND SUPPORT

The ETL personnel I coordinated with were exceptionally cooperative in answering my questions and in setting me up so I could exercise and evaluate the prototype.

The evaluation guidelines appeared to be a bit too technical for use by users who are not technically literate in the map graphics arena.

The users manual, as it applies to using EMD, was adequate. The inclusion of an ACRONYM Glossary would be helpful.

**PM, COMBAT TERRAIN INFORMATION SYSTEMS (CTIS)**

**DIGITAL TOPOGRAPHIC SUPPORT SYSTEM (DTSS)  
QUICK RESPONSE MULTICOLOR PRINTER (QRMP)**



1 May 1991

### EMD PROTOTYPE EVALUATION

The EMD Prototype was evaluated based on its usefulness as a map background for the Digital Topographic Support System (DTSS). Map backgrounds will be used on DTSS to serve as a reference for selecting coordinates for site locations as well as a back drop for displaying Tactical Decision Aids (TDAs). The first use requires accurate coordinate extraction from the map background image. The second requires accurate geographic reference in order to correctly overlay associated TDAs. Of the two DTSS map background requirements both could be satisfied by compressed ADRG to some extent. Both compressed ADRG and the map separates offered by EMD would satisfy the site extraction requirements. ADRG would also serve as a background for TDAs, but may be too cluttered when certain products are overlayed. The allure of map separates is to enable the user to display only those features that are of interest. For example, when displaying products, the only portion of the map background needed may be the cultural overlay which provides towns and road information.

Evaluator: USAETL, Geographic Systems Division - DTSS

Evaluation Hardware: Zeos 386, Logitech Mouse  
DOS 4.1  
NEC CD-ROM reader  
VGA monitor, 1024 x 768  
150 MB disk, 4MB RAM

Current Hardware: Portable ASAS Workstation (PAWS):  
-Ruggedized Micro VAX II  
-Parallax 1280 graphics board  
-VCB02 graphics board  
-(2) 760 MB disk drives  
-Sony Video disk player

### Development stage:

Currently in Full Scale Development, FUE is September 93. EMD, or its equivalent, would be implemented in Block 1 of the Pre Planned Product Improvement (P3I) Plan. The target hardware for P3I is currently unknown.

### Format and File structure:

The format and file structure used for the EMD prototype

appears to be sufficient. Our biggest concern is that consistency is maintained with respect to DMA products. The fact that EMD would be consistent with ADRG is definitely a plus. If ISO 8211 will be used by DMA in the future, then it is an acceptable format for EMD.

#### Data Structure and Compression Methods:

The data structure and compression methods used for EMD are both acceptable.

#### Utility of Prototype Data Set:

The images provided by EMD, or any other map background will never be used as a base for extracting data in order to create TDAs. Because of this, the loss of certain features when viewing separate layers does not pose a problem for DTSS. For normal operations, the only time an image would be decluttered is when overlaying TDAs onto the map background image. The layers most important for DTSS use would be the road-culture and the contour layer. The vegetation layer would probably not be used when overlaying products, since a better representation of the vegetation can be obtained from the Interim Terrain Data (ITD) used by the DTSS. Both surface drainage and the road network can also be obtained from ITD, but their representation on a typical map sheet is more useful than the vegetation layer. The desired order of map background requirements is decluttering, minimize storage, and consistent color across map sheets. The display order of layers that would be most useful for DTSS is from bottom to top: vegetation, drainage, contours and culture. The layer color and patterns should be similar to those found on the map sheet. It would not be useful to limit the number of layers to any less than the four used for the 1:50,000 TLMs.

#### Resolution:

Several of the maps provided in the EMD prototype were of very poor quality and in some cases the text was unreadable. This was most evident in the contour layer of the Fulda 1:50000 map. The cause of this is not obvious and could be related to the resolution or the quality of the scanning job. We are reasonably sure that the source material did not cause the poor quality, since we have the same coverage for the PAWS Display Manager (PDM). As part of our evaluation we compared the Fulda TLM distributed with the EMD prototype to the same map in the PDM data set, which was scanned by the Martin Marietta Corporation. The contour lines of the EMD data were very washed out and several of the labels were unreadable. However, the PDM contained a much cleaner and legible image of the same geographical area. Since the contour layers found in other map sheets released with the EMD prototype were much clearer it seems as though the poor

quality is related to the quality of the scanning. From looking at the prototype it is obvious that if EMD were to go into production, a better method of scanning and quality control would have to be incorporated.

#### Media:

CD-ROM does serve as an acceptable distribution media because it is consistent with DMA products. In DTSS operations the data would be loaded onto the hard disk from the CD-ROM. Any applications which required a map background would then access the maps directly from the hard disk.

#### Applications:

As mentioned previously, the DTSS makes use of a map background for selecting coordinates for use in TDA generation, and as a background for overlaying products. Future DTSS requirements include providing a terrain visualization capability by draping map images over elevation data. Because no data will be accessed directly from the CD-ROM, it is not mandatory that DMA products be distributed on the same disk. Using the same disk for all products over the same area would provide the users with an easy way of filing the disks. The products that DTSS would need on the same disk are EMD, DTED, and ITD. We have no requirement to view a map background in a night environment.

#### Summary:

DMA video disks currently provide the map background functionality for the DTSS. The graphics hardware of DTSS does not support the 24-bit data provided by ADRG, and the recent emergence of non-standard 4-8 bit ADRG came after our requirements were frozen. The PDM mentioned above is used on the DTSS-Prototype (DTSS-P) but will not reside on the initial DTSS. If compressed ADRG were available as a standard DMA product, it probably would meet the map background requirements of DTSS. Although separates will provide a decluttered image to overlay TDAs on, the final product of DTSS is hard copy plots. The image on the monitor is used by the terrain analyst in preparing products, not for decision making. If EMD were available, it would provide a map background capability superior to video disks, and more flexible than ADRG.

#### Evaluation Documentation and Support:

The evaluation software and accompanying documentation were very useful and self explanatory. DCAC personnel were helpful in answering questions resulting from our initial examination of the data set. One recommendation for future evaluations is to

provide different evaluation criteria for users and developers.

If you have any questions concerning this evaluation please contact Mr. Bob Gooding (703)355-3165.

## **EMD PROTOTYPE EVALUATION**

**U.S. Army Topographic Engineering Center  
Francis A. Ward  
Topographic Developments Laboratory (TDL)  
Graphic Systems Development Branch  
(Project: Quick Response Multicolor Printer - Prototype)  
Fort Belvoir, VA 22060-5546  
(703) 355-2769; ICOM #2514**

#### Hardware used for EMD Prototype Evaluation:

Zenith 248  
DOS version : 3.21  
Hard disk size : 21M  
Size of RAM : 640K  
Type of Monitor : EGA  
Type of Mouse : Logitech  
Type of CD-ROM reader : NEC CD-ROM reader

Our computer environment consists mainly of MACINTOSH. It would be better if the software is also available for this type of machine. Our lab consists of Macintosh computers, Syquest and Bernoulli disk drive systems, Laserwriter, CD ROM reader, PostScript Driver/High speed buffer, Intelligent Processing Unit, CANON Large Format (24" x 30") and Medium Format (11" x 17") Color Printers.

#### Summary of evaluation effort

An area was chosen among available source graphics. The selected region was then zoomed in and out by 4X. Colors/patterns of layers were changed to obtain various views and layer order was rearranged. These steps were repeated for almost all of the available source graphics.

#### Description of target system

The custom development contract for a Quick Response Multicolor Printer (QRMP) was terminated in December 1990. A decision was made to continue the program through the use of Commercial Off-the-Shelf (COTS) equipments to fulfill the requirements for a large format color printer. We have just finished procuring the equipments and are now in the stage of testing them. Our hardware configuration of the prototype consists of CANON large format (24" x 30") color printer, CD-ROM reader, Macintosh and IBM compatible computers. We will have to perform numerous tests/studies prior to awarding another QRMP contract. We welcome all types of digital map background product to perform our studies. The new QRMP contract award is tentatively scheduled to be in early or mid FY92.

#### Map Background Issues

We have just started to work with digital data; therefore, we do not have much input in this evaluation effort. From what we have seen of the EMD prototype, it appears to be a promising product and we strongly feel that this type of data will be useful. We have been printing ADRG data using the CANON Laser Color Copier (with a maximum format of 11" x 17"). In the near future, we plan to build a digital input into the CANON large

format ( 24" x 30") color printer and be able to output ADRG and other digital data to it.

### Compression Methods

Small/compressed file is good in terms of achieving faster processing time, though having only 1 bit/pixel does not give very good color. We do not know any compression methods or other run-length encoding techniques that would be better for the EMD product; however, we advocate compressed data as long as the output quality is not drastically reduced.

### Utility of Prototype Data Set

Having the ability to output color separates is great, though we place more concentration on storage requirements, resolution and quality of outputs. We have many uses for color and pattern assignments and little use for assignment of layer order.

Order of importance:

- #1 minimization of storage requirements
- #2 color normalization across map sheets and decluttering by color separates

### Resolution

The EMD resolution appears to be adequate for our requirements; though the higher the resolution, the better the product.

The resolution worsened when zoomed in or out from 2X to 4X. When an area is zoomed out by 4X, text became illegible, and roads/lines/borders appeared to run together. When zoomed in by 4X, the text appeared less smooth and pixels were more obvious. Zooming in and out at 2X appears to be adequate. (Maps were not received to do any comparison.)

Media: CD-ROM is the best form for distributing EMD.

Applications: We have many uses for EMD and digital map based products. We need these data to test the capability of accepting and processing digital data of our color printers.

Applications Software: One disadvantage of the software is when a map is scrolled, the screen becomes blank for a few seconds before a new view of the map appears, it would be better if the user could see the map areas while moving over it.

**U.S. ARMY CENTER FOR ELECTRONIC WARFARE/REMOTE  
SURVEILLANCE TARGET ACQUISITION (EW/RSTA)**



13 December 1990

## EMD PROTOTYPE EVALUATION

### 1) BACKGROUND

This Electronic Map Data (EMD) Prototype evaluation effort is designed to further define the Army's requirement for a digital map background product. Army has stated that the currently available map background product, Defense Mapping Agency's (DMA) Arc Digitized Raster Graphics (ADRG), does not fully satisfy Army's requirements. A survey conducted in 1st quarter FY88 demonstrated a strong need for a product which would require minimal storage, support decluttering, and normalize color across map sheets. A formal statement of this requirement was prepared by the Office of the Deputy Chief of Staff for Intelligence (ODCSINT), who also proposed a prototype development effort based upon this requirement statement.

The EMD Prototype was developed to meet the Army's stated requirements, and, as nearly as possible, to be compatible with the specifications for DMA's ADRG. In a separate effort, DMA is investigating the possibility of providing ADRG in a compressed form. It is necessary to determine whether or not a compressed ADRG would meet essential Army requirements, or whether a standard based on an EMD-like product is merited. The U.S. Army Engineer Topographic Laboratories (USAETL) intends to prepare a map background requirements statement and a revised (if necessary) product specification based upon user response to this evaluation.

### 2) EVALUATION REPORT GUIDELINES

#### EXECUTIVE SUMMARY

##### Summarize Evaluation Effort

#### EVALUATION TEST BED ENVIRONMENT

##### Identify Organization and Project/Program Name

US ARMY CECOM, Center for EW/RSTA, Systems Engineering Division, SANDTABLE Project

##### Specify Point-of-Contact and Address

Dennis Lui/Hung Le US Army CECOM, AMSEL-RD-EW-SE, Ft. Monmouth, NJ 07703-5000

##### If Contractor, Describe Relationship to Government

##### Sponsor/Program

##### Describe Hardware/Software used for EMD Prototype Evaluation

Type of IBM PC or Compatible Computer (example: Zenith 248, Compaq 286/386, etc.)

DOS Version

Gateway 2000 386, DOS Version 4.01

Describe Hardware/Software used for EMD Prototype Evaluation  
(Cont.)

Hard disk size (40 Megabytes, etc.) 110MB  
Size of RAM (Kilobytes or Megabytes). Minimum 640K 4MB  
required.  
Type of Monitor (EGA or VGA) VGA  
Resolution of Monitor 1024 x 768  
Type of Mouse (Logitech or Microsoft) Microsoft  
Type of CD-ROM reader Sony

The EMD prototype was developed for a low-end PC environment with minimum hard disk and RAM requirements. Is this representative of the PC environment within your organization? If no, please describe. No, target system will be a 386 Compatible with 100 MB removable HD & 4 MB of RAM.

DESCRIPTION OF TARGET SYSTEM(S)

If applicable, please specify as follows: OFF THE SHELF HARDWARE

Describe Stage of Development N/A

Identify System Fielding Date N/A

Indicate Probable Date for Needing EMD or Similar Digital Map Background Product N/A

Describe Hardware/Software Configuration of Target System(s) N/A

MAJOR EVALUATION ASPECTS

Format and File Structure

Review the EMD prototype product specification and provide comments and recommendations pertaining to the prototype format and file structure. Describe any alternate format and/or file structures that could improve access time, further minimize storage requirements, and/or provide a better structure for developing future application software. N/A

ISO 8211 is normally used as a transfer standard, however, it may serve as a distribution format. Was ISO 8211 utilized to its fullest potential within the EMD prototype? Should something other than ISO 8211 be used? If yes, please describe and justify. N/A

Provide any additional concerns or comments relating to EMD format and file structure that were not addressed above.

N/A

## Data Structure

EMD images are built using 512 pixel by 512 pixel tiles. Do you have a need for a different tile size? If yes, please describe the required size. Keep in mind that tile size affects the speed of display.

NO

Provide any additional concerns or comments relating to the EMD data structure that were not addressed above.

NO

## Compression Methods

The EMD Prototype uses a one-dimensional run-length encoding technique. Are there additional compression methods or other run-length encoding techniques that you feel are better for a product such as EMD?

## Utility of Prototype Data Set

Map features often overlap, or overprint, one another (e.g., roads cutting through cities, names on vegetated areas, etc.). This has implications for a digital product based upon the individual color separates. For example, when showing only the vegetation overlay, it is possible that a "gap", corresponding to the position of a road, will be present. In addition, because only one color is shown for each pixel location, the ordering of the layers on the display monitor may be important (e.g., if the transportation network is most important to your application, it would be most reasonable to display the transportation file last, or "on top" of the other layers displayed).

The "gap" corresponding to the position of the road may affect our task. Another characteristic of color separates is that not all features appear entirely on one separate. The principal example is that of highways and improved roads, which are comprised of a brown fill and black casing. The result is that both the black and brown files must be displayed to completely depict all roads.

### NO CONCERN

Please comment on the impact of the EMD characteristics stated above. Indicate whether these phenomena make the data set unusable, or describe how you compensated for these effects. Also comment on which layers you typically found most important.

### ROADS & NAMES

Rank in order of importance, your requirement for each of the following: a) decluttering by color separates, b) color normalization across map sheets, and c) minimization of storage requirements.

a, c, b

In your routine operations, would the EMD need to be transformed (reformatted or restructured) for a particular system? If yes, describe the system and required format.

NONE

### Utility of Prototype Data Set (Cont.)

EMD provides the capability to display the layers in any order. Which order most fits your application? ROADS, CULTURE, RELIEF, VEGETATION CULTIVATED LAND, VEGETATION

Describe the layer color and pattern assignments that were most useful. FLEXIBILITY OF ASSIGNING COLORS & PATTERN MET OBJECTIVES.

Could certain layers be combined and still meet your requirements? Describe why or why not and which layers. NO

Provide any additional concerns or comments relating to the utility of the prototype that were not addressed above. N/A

### Resolution

The EMD Prototype was scanned at a 100 micron resolution. Displaying an EMD image at 1:1 depicts this resolution. Is this sufficient for your requirements? For example: Was all text legible, how did it compare to the paper maps, etc? By zooming out 2x, this display represents an equivalent scanning resolution of 200 microns. Is this resolution sufficient? Please discuss.

### Media

Is the CD-ROM acceptable for distribution of the EMD? YES

In normal operations, would you anticipate EMD be loaded onto another media type (i.e., hard disk)? If yes, please describe media type and reason(s) for transferring to this media.

YES, IT WILL BE LOADED TO THE HARD DISK FOR FASTER ACCESS.

### Applications

Describe intended uses of EMD or similar digital map background product. MISSION PLANNING AND DEMO

Would you prefer to see EMD distributed by itself or combined with other products (e.g., ITD, DTED, etc.) on the same distribution media? Please describe which products.

EMD WITH ITD & DTED

Is there a requirement to use EMD in a night environment? If yes, please describe.

NO

### Map Background Issues

Many evaluators have experience with DMA's Arc Digitized Raster Graphics (ADRG). If applicable, please address the following questions to the best of your knowledge.

Describe briefly your experience with or knowledge of ADRG.

WE HAVE USED FOR DEMO AND DISPLAY

### Map Background Issues (Cont.)

Are you currently using ADRG or a compressed form of ADRG? If yes, describe application and any transformations performed.

YES, USED TO DISPLAY AREA OF INTEREST IN SANDTABLE PROJECT

If a compressed form of ADRG (4, 6, or 8-bit) were available, would you still have a requirement for EMD? If so, describe the advantages and disadvantages of each product as it applies to your map background requirement(s).

NONE

Would benefits of EMD over ADRG merit adoption of EMD as an Army map background standard? If so, would you be interested in funding production of EMD?

NOT NECESSARY, AND WE WILL NOT BE INTERESTED IN FUNDING THE PRODUCTION

### Applications Software

The application software provided with this prototype is only intended to assist in the evaluation. However, any comments on the software will assist DCAC in evaluating other comments and help improve future efforts.

What are the most and least important features of this software?

MOST IMPORTANT FEATURES ARE DECLUTTERABILITY, ASSIGNING COLORS, AND GAZZETTER

Describe other functions, not included in the prototype applications software, which you would require in an operational environment.

N/A

### Recommendations

Please provide recommendations for Army and DMA regarding the future course of EMD or similar digital map background product. Also provide any additional recommendations concerning evaluation topics addressed above.

N/A

### Evaluation Documentation and Support

Please provide comments on the evaluation guidelines and support you received from DCAC personnel as part of this evaluation. This information is necessary for future prototypes and evaluations to be successful.

EXCELLENT

Provide comments on the EMD Users Manual, EMD Prototype Product Specification and Jewel Box Pamphlet. Were they adequate for you to complete the evaluation?

YES, ADEQUATE

## BIBLIOGRAPHY OF KEY EVALUATION DOCUMENTATION

1. Prototype Product Specifications For Electronic Map Data (EMD), Final Draft, 1 October 1990
2. Electronic Map Data Application Software User's Manual, November 1990
3. EMD Prototype Evaluation Guidelines
4. EMD Prototype Jewel Box Pamphlet
5. Maps

**U.S. ARMY CENTER FOR SIGNAL WARFARE**



DEPARTMENT OF THE ARMY  
U.S. ARMY COMMUNICATIONS-ELECTRONICS COMMAND  
CENTER FOR SIGNALS WARFARE  
VINT HILL FARMS STATION, WARRENTON, VIRGINIA 22186-5100

REPLY TO  
ATTENTION OF

15 MAY 1991

AMSEL-RD-SW-TRF (70-1y)

MEMORANDUM FOR Commander and Director, U.S. Army Engineering Topographic  
Laboratory, ATTN: CEETL-CA-S (John Bradley), Fort Belvoir,  
VA 22060-5546

SUBJECT: Limited Evaluation of the Electronic Map Data (EMD) Prototype

1. The purpose of this memorandum is to provide feedback from this Center's limited evaluation of the Electronic Map Data (EMD) prototype (completed by one of the Center's Computer Scientists, Mr. Terence Cronin) which was sent to us in December of 1990. This action is a follow-up to a telephone conversation between Mr. Terence M. Cronin, USAC<sup>2</sup>SW, and Mr. John Bradley, USAETL, on 9 May 1991.

2. The Center's research group strongly supports your efforts in developing the EMD prototype. The research group has realized for some time that map data is sorely needed by virtually all Army agencies in order to fulfill their research and technology mission areas. In this Center's case, we have had map reasoning algorithms sitting in the hopper for nearly three years, waiting for the availability of real data with which to ring out the software logic. Your efforts go far in bridging the gap between what DMA can provide the Army, and what the Army laboratories and centers actually need right now for their R&D efforts.

3. In March, one of our resident engineers, Mr. Mark Fine, installed the EMD software on a PC compatible system located in-house at the Center. The hardware suite consisted of a Vanguard Microsystems 386 with math coprocessor (387). Features include DOS 3.3 IBM operating system, 40 MB hard disk, 4 MB RAM, VGA monitor, SVGA resolution, Logitech mouse, and Sony BSR CD-ROM reader.

4. As per above telephone conversation, Mr. Cronin's interest in the prototype is primarily motivated by a need for vectored map separates to serve as inputs for computational geometry algorithms developed in-house with basic research funding. Therefore, during the evaluation process, Mr. Cronin focused on that portion of the EMD software which addressed the issue of interim terrain data (ITD), which was available for several cells in the Killeen, Texas area of Fort Hood.



AMSEL-RD-SW-TRF

SUBJECT: Limited Evaluation of the Electronic Map Data (EMD) Prototype •

5. Mr. Fine had no problem installing the software and executing the program, although Mr. Cronin pointed out that Mr. Fine is a very talented engineer who is more highly skilled in the IBM DOS environment than is the typical user. The User's Manual (containing installation instructions) provided with the package was exemplary for both its clarity and conciseness.

6. Turning to the ITD option in the "Other Information" menu of the prototype, we can truly appreciate the size of the files for the color separates, particularly for vegetation and obstacle data, but the time required to display the separates is prohibitive. Also, some of the feature separates indicated on the 1:50,000 hardcopy map are not contained in the digital product - there are both secondary roads and certain drainage features which do not show up on the screen. As a final point, Mr. Cronin posed the question about why the ITD data is represented as color separates - it is his understanding that it is DMA's intention to provide the data as a feature separate representation in a spaghetti vector format. This disparity is confusing to Mr. Cronin.

7. As a result of viewing your prototype, Mr. Cronin has decided to focus his near-term map reasoning work on the Killeen area. In April, Mr. Cronin met with Alan Geralnick at your installation, and he has provided Mr. Cronin with attributed feature data for the 1:50,000 map containing Killeen. Mr. Cronin has also been in touch with Rockware, Inc., a Colorado firm in the business of selling earth science-related software. Our research group has ordered a package called MacGridzo, which is capable of generating topographic contours, given a set of input coordinates at a specified elevation; in addition, the four 7 1/2 degree quads of the Killeen map have been ordered with the package. It is Mr. Cronin's intention to install all of the data files and software on a MacIIfx workstation within the next year or so.

8. Regarding the hardware compatibility, are there any plans to make the EMD portable to machines outside the PC environment? The ASAS Program Office needs to support the MicroVax workstation. Also, the Data Fusion Testbed and IEW Modeling and Simulation efforts employ the following computers: Sun Sparc Station, MacIntosh IIfx, and Hewlett Packard Scientific Workstation. If the EMD were available for a variety of architectures, it seems it could be utilized to its full advantage to provide a service to as wide an Army user community as possible.

AMSEL-RD-SW-TRF

SUBJECT: Limited Evaluation of the Electronic Map Data (EMD) Prototype

9. This Center has a continuing interest in receiving revisions and upgrades to the EMD product, and also would like to continue to participate in the evaluation process. The comments contained in this letter are meant to be constructive criticism of the prototype, and hopefully some of the suggestions might be incorporated into your long-term planning for the effort. Thank you for thinking of this Center when you solicit new inputs.

10. POC for this action is Terence M. Cronin, DSN 229-6939.

11. CECOM Bottom Line: THE SOLDIER.

FOR THE DIRECTOR:



RICHARD A. POISEL

Chief, Research and Technology Division

**U.S. ARMY ENGINEER SCHOOL**

**EVALUATION OF THE ELECTRONIC MAP DATA PROTOTYPE**  
**United States Army Engineer School**  
**May 1991**

**I. Executive Summary**

The evaluation of the Electronic Map Data (EMD) Prototype was conducted by the Department of Topographic Engineering and the Directorate of Combat Developments of the United States Army Engineer School (USAES) during the months of February, March, and April 1991. The goal of the study is to provide the Engineer Topographic Laboratories (ETL) with an end-user oriented study to assist in identifying and evaluating critical issues in raster map data development. The evaluation process closely followed the guidelines provided in the EMD Prototype data package.

1:250,000 and 1:50,000 EMD map images over Germany and Fort Hood, Texas were evaluated both by individual layer and in their composite form. These displays were compared to the hardcopy map source to assess overall image quality. Areas of feature density containing text, overlapping information, and small icons were evaluated most carefully in order to assure data retention and legibility. Throughout the analysis, functionality of the database and the application software was tested.

Several conclusions have been reached regarding EMD. The stated Army requirements of data storage reduction, decluttering, and color normalization were validated by the prototype. CD-ROM as a distribution media proved acceptable. The image quality of the prototype, however, is unacceptable. Text and small icons are often blurred and/or illegible. Further, the source required to produce EMD is undesirable in terms of availability and the number of graphics necessary to create a single map image. While it is worthwhile to pursue the Army requirements, it is suggested that alternative scanning methodologies be investigated. Foremost among which is technology that enables scanning of separate color files from a composite source.

**II. EVALUATION TEST BED ENVIRONMENT**

**A. Primary Evaluators:**

Mr. Jeff Faunce  
U.S. Army Engineer School  
ATTN: ATSE-TEE  
Fort Leonard Wood, MO 65473-6640  
AV 676-5709, Comm (314) 563-5709

SFC Paul Lake  
U.S. Army Engineer School  
ATTN: ATSE-CDM-T  
Fort Leonard Wood, MO 65473-6640  
AV 676-7998, Comm (314) 563-7998

**B. Test Bed Hardware/Software:**

Zenith 286, MS-DOS Version 3.21  
60 MB Hard disk capacity  
640K RAM  
Zenith EGA monitor, 640 x 480  
Logitech mouse  
Hitachi Model CDR 15035 CD-ROM  
reader

**III. DESCRIPTION OF TARGET SYSTEM**

Identification of a target system is not applicable to this evaluation.

**IV. MAJOR EVALUATION ASPECTS**

**A. Format and File Structure - Not evaluated.**

**B. Data Structure -** The tile size as distributed with the EMD Prototype is not optimal for day to day operations. The area capable of being displayed at the original resolution should be larger than the approximate 2 km X 3 km for 1:50000 source and 9 km X 15 km for 1:250000 source. While it recognized that a larger tile would slow display time, the resultant image would be of a more utilitarian size (e.g. 5 km X 5 km for 1:50000). This would enable the soldier to work over distances and areas more commonly required in normal operations. In instances where the image needed enlargement, this could be accomplished via the zoom functions.

**C. Compression Methods - Not evaluated.**

**D. Utility of Prototype Data Set -** The functionality of the EMD prototype was, for the most part, quite satisfactory. The following paragraphs discuss various issues relating to this functionality.

**Data Gaps**

Data gaps in image files do not present an unworkable problem. While it is true that line features and polygons are often interrupted in the database, gap questions left unresolved after viewing a single layer can be answered by adding the appropriate layer to identify the activity

occurring in that space.

#### Color Separability

EMD, as described in the documentation, is color separable rather than feature separable. While this presents a problem in the creation of a pure feature layer such as transportation, it represents a reasonable compromise to the additional editing effort required to create a truly feature separable database.

#### Army Raster Map Requirements

For a raster map database to be successfully implemented, it is important that the stated Army requirements be met as fully as possible. Ranking, in order of importance, of the specific EMD answers to these requirements is as follows: 1) minimizing of storage requirements, 2) decluttering by color separates, and 3) color normalization across map sheets.

#### Layering Functions

The layering functions of the EMD prototype provide valuable flexibility for the presentation of map sheet information. Though the ability to re-order layers is appreciated, our evaluation found the following order of files (from bottom to top) to be most helpful: 1) vegetation, 2) contours, 3) hydrology, 4) culture, and 5) aeronautical. Much of the utility of EMD, however, relates not to the ordering of layers, but rather, to the ability to suppress certain information from display. This can be a great aid in the clear, concise presentation of information. It follows, then, that the pre-combining of layers is not advisable. Such combining would impose too heavy a cost on the overall flexibility of the database. Even in the event that pre-combined files could be presented in addition to individual files, the data storage penalty would more than offset any added convenience.

#### Color Issues

The requirement for color normalization across map sheets is fully met by the EMD prototype. The default color attachments are satisfactory in most instances, though other color and pattern combinations have certain applications. There is a tendency, for example, for the brown layer to dominate in heavily urban settings. This can be relieved by changing the solid color to a stippled pattern. There are also instances where text and line work are hard to distinguish in the hydrology and aeronautical layers. Such features can be made more legible by attaching a darker color to the file. Finally, the ability to attach various colors to map data not only achieves color normalization across map sheets, but also

allows the user to highlight areas of special significance to a specific mission.

#### Source Information

The source information and source quality modules of the EMD prototype are very well implemented. As all final products are directly influenced by and dependent upon current and accurate terrain information, the data provided in these menus is critical. The appropriate details are all stated and presented in a very legible manner. This type of information should be standard to all digital map databases.

#### Legend Information

The ability to display legend information in the prototype is not well executed. Such information is especially important to those lacking experience in reading maps. Unfortunately, a great deal of manipulation is required to find and display the required data. Additionally, in many instances, not all the information is able to be displayed on a single screen. These shortcomings might be alleviated by dividing the legend data into topical subsets and reconfiguring the legend so that the bulk of the material could be viewed on a single display.

**E. RESOLUTION** - Evaluation of the scanning resolution of the EMD prototype was inconclusive due to the inconsistent quality of the product. Quality varied not only from graphic to graphic but also within individual graphics. Problems most often perceived include blurring of small text and icons, bleeding together of closely spaced contour lines, and poor registration of the "roads" layer. Landmark icons such as churches or schools are also lost to the user. Further, in areas of apparent equal feature density, one area may be represented quite adequately while another is nearly illegible. This results in unacceptable loss of information.

Polygon and line features are the most consistently well represented. The quality of polygons, especially, remain constant throughout the various manipulations.

Each image was viewed using all available zoom functions to check retention of image quality. The "in" zoom operations resulted, as expected, in a more blocky representation. The ground distance covered by these zooms is so small as to not be particularly useful. While it is an aid in reading smaller text, this function might be better executed by including a draggable magnification window in the software.

EMD "out" zoom functions were evaluated to determine

if the scanning resolution could be enlarged. The "out 2x" zoom exhibited the ability to give a broader view of an area, but also degraded the image quality. The quality of an image at this resolution is sufficiently poor to rule out 200 microns as an acceptable scanning resolution. The "out 4x" zoom results in a virtually unusable image and is, therefore, of little utility.

**F. MEDIA** - CD-ROM is an acceptable distribution media for EMD. Because access time from the CD-ROM is somewhat slow, it is anticipated that, under normal operations, the data will be loaded to hard drive.

**G. APPLICATIONS** - It is anticipated that raster map background data will most often be used as a backdrop or georeferencing layer upon which other information will be overlaid. Such information might be in the form of vector formatted feature data (such as roads), military symbols generated by applications software, or specific terrain information products (such as line-of-sight data). When used in combination with other digital data, map background information is used to produce situation maps, threat overlays, and various terrain support and terrain visualization products.

Because EMD would most often be used in conjunction with other digital data, it should be distributed with Digital Terrain Elevation Data (DTED) as a minimum, and Interim Terrain Data (ITD) or Tactical Terrain Data (TTD) where available.

**H. MAP BACKGROUND ISSUES** - Experience with Arc Digitized Raster Graphics (ADRG) is limited to simple visual displays using the ADRG module within the Terrabase software. The exposure to ADRG does, however, point out that a better quality map background image should be expected in the EMD product. Provided that this image quality issue can be solved, the improved functionality of EMD over ADRG (as stated in section C.) makes it worthwhile to pursue such a product. The source of EMD, however, is a significant problem. A minimum of four color separates are required to produce a single map image. This is not acceptable. Not only is there a cost in terms of production time and source availability, there seems to be, as illustrated in the EMD prototype, a registration problem among the separates. It is suggested that alternate technology be investigated that enables separate color files to be derived from a single composite source.

**I. APPLICATIONS SOFTWARE** - The applications software provided with the EMD prototype was sufficient to support an evaluation of the data. The ability to change the



hierarchy of image layers and toggle layers on and off is well developed. In real-world applications, it would be desirable to include functionalities commonly found in existing map background software. Such functionalities include pan and roam via Military Grid Reference System coordinates or place name (gazetteer), draggable magnification window, draw packages for overlay development, etc.

**J. RECOMMENDATIONS** - Refer to recommendations previously stated in this report.

**K. EVALUATION DOCUMENTATION AND SUPPORT** - The evaluation guidelines provided with the EMD prototype were very helpful in the preparation of this report. All accompanying documentation was sufficiently supplied and useful. This format could be successfully utilized in future evaluations with little revision.

**U.S. ARMY SIGNAL SCHOOL**



DEPARTMENT OF THE ARMY  
HEADQUARTERS U.S. ARMY SIGNAL CENTER AND FORT GORDON  
FORT GORDON, GEORGIA 30905-5000



REPLY TO  
ATTENTION OF

ATZH-CDM (70-1i)

26 APR 1991

MEMORANDUM FOR Commander, U.S. Army Engineer Topographic Laboratories, ATTN:  
CEETL-CA-S (Kevin Logan), Ft Belvoir, VA 22060-5546

SUBJECT: Electronic Map Data (EMD) Prototype Evaluation

1. References:

a. Meeting between your organization and Signal Center representatives, DCD, 26-27 Mar 91, SAB.

b. Memorandum, CEETL-CA-S, 12 Mar 91, SAB (encl).

2. The purpose of this memorandum is to provide you SIGCEN's evaluation of the EMD per your request (Ref a. and b.).

3. The SIGCEN evaluation is based on Subject Matter Experts (SME) participation which included input from the Directorate of Combat Developments, Battlefield Spectrum Management Course, and Signal Leadership Departments.

4. A consolidated summary of SME input follows:

a. The EMD demonstration was very informative and points out the need for a map overlay capability in the communications system planning, radio spectrum management, and interference resolution and reduction areas. The EMD was shown to be better than the current video disk function used with the Electromagnetic Compatibility Assurance Software (EMCAS i.e. Army Frequency Engineering Software (AFES).

b. The ability to remove the clutter from a map by deleting or de-emphasizing objects is of paramount importance. The ability to import other symbols for specific operations or exercises adds greatly to the capability.

c. Ranking of Features: The most important features to users are in prioritized order (number 1 most important).

- (1) Decluttering
- (2) Interim Terrain Data (ITD)
- (3) Storage Requirements
- (4) Color Normalization

ATZH-CDM

SUBJECT: Electronic Map Data (EMD) Prototype Evaluation

d. The EMCAS (AFES) system would be greatly enhanced by including this capability. One of the major shortcomings of automated network planning software is that after the computer finds area high points, a person has to get paper maps and validate each location. This time could be saved if the planner could overlay the 1:50,000 map on the same screen he is using for the network planning. The ITD capability would further enhance this by providing average tree height and tree density information.

e. Most Useful Layer, Color and Pattern: Based on the users review of the "layers" on the display model monitor, color and pattern assignments are prioritized as follows (number 1 most important).

- (1) Vegetation - bottom
- (2) Aeronautical Data
- (3) Relief Shading
- (4) Cultural
- (5) Landmark Bands
- (6) Roads
- (7) Hydrology
- (8) Contour Lines
- (9) Grid Markings

f. Media needs to be usable from both the CD-ROM and hard disk for ease of use and speed of operation. Many users may not be able to free up the needed space on the hard drive so both options need to be available.

5. POC for this action is Don Jones, DSN 780-7178.

FOR THE COMMANDER:

Encl

  
SHIRLEY E. BLACKBURN  
Admin Officer

CF:  
SLD, ATZH-SLD, ATTN: C, SWOD  
DOTD, TD  
DCD, C&S



**DEPARTMENT OF THE ARMY**  
**UNITED STATES ARMY ENGINEER TOPOGRAPHIC LABORATORIES**  
**FORT BELVOIR, VIRGINIA 22060-5546**

CEETL-CA-S (70-1r)

12 March 1991

MEMORANDUM FOR COMMANDER, U.S. ARMY SIGNAL CENTER AND FORT  
GORDON, ATTN: ATZH-CDM (DON JONES), FORT  
GORDON, GA 30905-5090

SUBJECT: ELECTRONIC MAP DATA (EMD) PROTOTYPE EVALUATION

i. References:

a. Meeting between your organization and the Digital Concepts and Analysis Center (DCAC), 25 January 1991, subject as above.

b. Memorandum, USAES, ATTN: ATSE-CDM-T, 17 January 1991, subject as above.

2. DCAC is currently performing an evaluation of the EMD Prototype. This evaluation will aid DCAC and the Army in refining the Army's requirements for a raster-scanned digital map background product that minimizes storage requirements, offers a selective decluttering capability, and normalizes colors across map sheets.

3. DCAC requests your support in performing this evaluation by supplying subject matter experts to participate in a "Practical Exercise" and evaluate the EMD prototype at your facility.

4. DCAC will assist in the practical exercise by supplying one person, one computer system and all necessary software, documentation and guidance needed to perform the exercise.

5. The following schedule and plan is recommended for the Practical Exercise.

March 26, 1991 - 0800-1200 Equipment set-up and general discussions.

March 26, 1991, 1300-1700 - Practical Exercise, Session 1, two-three participants.

CEETL-CA-S

SUBJECT: ELECTRONIC MAP DATA (EMD) PROTOTYPE EVALUATION

March 27, 1991, 0800-1200 - Practical Exercise, Session 2,  
two-three different participants.

March 27, 1991, 1300-1700 - Complete evaluation documentation  
and final wrap-up

6. Please contact Mr. Kevin Logan, AUTOVON 345-2759, commercial,  
(703) 355-2759 for further coordination.

FOR THE COMMANDER AND DIRECTOR:

A handwritten signature in dark ink, appearing to read 'Francis G. Capece', is written over the typed name.

FRANCIS G. CAPECE  
Director, Digital Concepts  
and Analysis Center

**U.S. ARMY AIR DEFENSE SCHOOL**



DEPARTMENT OF THE ARMY  
HEADQUARTERS, US ARMY AIR DEFENSE ARTILLERY SCHOOL  
FORT BLISS, TEXAS



REPLY TO  
ATTENTION OF

19 MAR 1991

ATSA-CDS-CC (70-1b)

14 MARCH 1991

MEMORANDUM FOR COMMANDER AND DIRECTOR, US Army Engineer Topographic  
Laboratories, ATTN: CEETL-CA-S, Fort Belvoir, VA 22060

SUBJECT: USAADASCH Electronic Map Data Prototype Evaluation

1. A review of Electronic Map Data (EMD) demonstration software was conducted informally at DCD Fort Bliss, TX. A request for a formal review will require additional time and staffing. The EMD prototype has potential to support ADA engagement operations, force operations, staff planning and training with digital terrain data. However, overlapped features and low resolution made it difficult to visually interpret map information.

2. The hardware used is not representative of the PC environment within DCD. The computer configuration used to evaluate the software appears to meet minimum system requirements, which would explain the slow processing times. Symbols displayed on the monitor had elliptical distortion, assumed to be a monitor maladjustment. This PC environment lacks CD-ROM readers and hard disk sizes over 20 megabytes. The hardware/software used for EMD prototype evaluation follows:

IBM PC AT compatible computer system Zenith ZW 248  
DOS version 3.2  
Hard Disk size 20 meg  
Size of Ram 1.2 meg  
EGA monitor 640 X 350 resolution  
Microsoft Mouse  
Hitachi CD-ROM reader

3. The intended use of EMD type software for target system requirements are:

FAADS FY97+  
C2 nodes  
Ground Based Sensors  
Masked Target Sensors  
HIMAD FY93+  
C2 nodes

4. The Hardware/Software configuration of target systems will be in accordance with ATCCS requirements unless ATCCS cannot meet or develop equipment to support ADA requirements. ADA will process, send, and receive geometric map data to overlay existing map data contained in C2 system data bases. Digital Terrain data must be processed to determine line of sight for communication to facilitate networking of sensor information and command & control. Sensor coverage maps will be derived from processing of digitized terrain features to indicate blind spots or terrain masks. Aircraft transit corridors, no fire zones, political boundaries, and weapon system engagement coverage will overlay EMD. Currently Portable All Source Analysis Workstations (PAWS) can provide the mentioned EMD capabilities with higher resolution displays, printing, plotting, interactivity, communication and ADA functionality.



ATSA-CDS-CC (70-1b)

SUBJECT: USAADASCH Electronic Map Data Prototype Evaluation

5. C2 systems are required to be on the air in a short period of time after movement. Digitized terrain information needs to be preprocessed and available on demand. The use of CD-ROMs to store large volumes of map data make the system **very slow to retrieve data and establish map displays** on a 16 bit 80286 system. It would be more efficient to allow the user to preset conditions so that overlays that are needed are unpacked, processed, and displayed. The CD-ROM provides inexpensive mass data storage but may be too slow for ADA applications by themselves.

6. If possible, instead of using digitized grid line overlays, have the processor plot grid lines for a selected position and map scale. The computer generated grid lines would have more detail at any scale selected and would reduce the masking of map features.

7. POC for this action is CW3 Price, DSN 978-2486.

FOR THE COMMANDANT:



ALLEN P. HASBROUCK  
COL, AD  
Director of Combat Developments

**U.S. ARMY AIR COMBINED ARMS COMMAND**

## EXECUTIVE SUMMARY

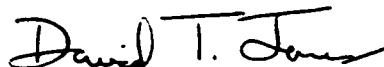
### Summarize Evaluation Effort

Evaluation of the Electronic Map Data prototype was conducted at US Army Combined Arms Command, Fort Leavenworth, KS. Participants included personnel from Command and Control Directorate, TRADOC Program Integration Office - Army Tactical Command and Control System (TPIO-ATCCS), TRADOC System Manager - Maneuver Control System (TSM-MCS), Future Battle Laboratory (FBL) and Command and General Staff College (CGSC).

We reviewed the product from an operational standpoint as opposed to a technical one. Therefore, we did not comment on technical issues such as use of ISO 8211 format. We looked at the prototype in terms of how it satisfies operational requirements.

In terms of Command and Control, we look at two primary functions for digital data bases: map backgrounds and terrain analysis. Based on our evaluation, we found the EMD prototype to be too limited to support either function. The types of things we would want to declutter are cultural features. However, eliminating the cultural features also eliminates the grids. The bottom line from those that evaluated the prototype was that the color decluttering was not useful substitute for feature decluttering. The limited color decluttering was also not useful in terms of terrain analysis.

The conclusion from our evaluation is EMD in its current form has no value to Maneuver Control System (MCS) or the Army Tactical Command and Control System (ATCCS).



DAVID T. JONES  
CPT, EN  
Action Officer

## EVALUATION TEST BED ENVIRONMENT

### Identify Organization and Project/Program Name

Combined Arms Command

Maneuver Control System (MCS) and Army Tactical Command and Control System (ATCCS)

### Specify Point-of-Contact and Address

CPT David T. Jones, (AV) 552-4283 or (913) 684-4283

CDR, USACAC

ATTN: ATZL-CDC-D (CPT JONES)

FT. LEAVENWORTH, KS 66027

### Describe Hardware/Software use for EMD Prototype Evaluation:

Type of Computer: Zenith 248

Hard Disk size: 20 Megabytes

Size of RAM: 640K + 1024K EMS

Type of Monitor: NEC Multisync (EGA)

Resolution of Monitor: 640 x 350

Type of CD-ROM reader: Hitachi

## MAJOR EVALUATION ASPECTS

### Format and File Structure

While we did not concentrate in depth on format and structure, we felt that there was some redundancy between the textual data files and some of the legends. Where textual information is found in both text form and as a image in the legend files, the image files should be eliminated. Only those image files that include graphics should be retained.

As far as ISO 8211 format is concerned, we favor any effort at standardization.

### Data Structure

We had no comments on data structures.

### Compression Methods

We had no comments on compression methods.

### Utility of Prototype Data Set

In most cases, evaluators preferred the default order of layers. We found no perceived benefit is changing the order.

The inflexibility of having features using more than one layer was perceived to be a problem. If we wanted to eliminate the contour lines, we could no longer differentiate between primary and secondary roads.

In order of importance, our needs are to minimize storage requirements, normalize colors across sheets and declutter by color. Even though the concept of color declutter was originally thought to be useful, this evaluation is proved out that it was not very useful at all.

We would anticipate no requirement to transform EMD if we wanted to use it. We would prefer if the spatial resolution was compressed to 127 pixels per inch.

Most users preferred to have the basic contour lines, hydrology, vegetation, roads and urban areas on their map backgrounds. The main classes of features of information which they wanted to declutter were aeronautical information and cultural information such as city names and special symbology. However, eliminating the latter features meant loss of roads and grid lines.

### Resolution

The 200 micron resolution is sufficient for our use. In addition, the 200 micron resolution most closely matches the resolution of display devices currently used by MCS and ATCCS.

### Media

**Is CD-ROM acceptable for distribution?** CD-ROM is an acceptable media for distribution. It is low cost and holds a great deal of data.

**Would you anticipate EMD being loaded onto another media type?** The CD-ROM was slow in loading the image. To speed access, the EMD data may be loaded on another media such as Magneto-Optical Disk or Hard Disk. Placing EMD on these other media also accommodates combining it with other data bases such as DTED or ITD.

### Applications

**Describe intended uses of EMD.** The primary use for EMD would be as a map background for displaying other information. EMD has some potential as an analysis tool but it is very limited. A feature data base such as TTD better supports this functionality.

**Would you prefer to see EMD distributed by itself or combined with other products on same distribution media?** We would prefer a combination of raster map background and digital terrain data (DTED and ITD). Ideally, one media with both data bases would be the preferred solution. However, since we would probably load the data onto some other device for on-line access, this is not essential.

**Is there a requirement to use EMD in a night environment? If yes, please describe.** MCS and ATCCS will operate in all light conditions. Since the current monitors are luminescent in nature, red-light readability is not required.

#### Map Background Issues

**Describe your experience with or knowledge of ADRG.** The majority of the individuals looking at the prototype have seen ADRG in the MCS E-Map format.

**Are you currently using ADRG or a compressed form of ADRG? If yes, describe application and any transformations performed.** The current form of ADRG is the MCS E-Map format which compresses ADRG to 16 colors and spatially compresses the image from 254 to 127. The color compression uses a least distance algorithm. It is necessary because of hardware limitation. The spatial compression is needed to increase the area displayed on the screen. Our displays have a resolution of approximately 100 pixels. By compressing to 127 pixels per inch, we achieve a resolution close to the resolution of the monitor.

**If compressed form of ADRG were available, would you still have a requirement for EMD?** Either a ADRG compressed to 4 color bits and 127 pixels per inch or EMD is acceptable. Our main requirement is for a compressed image which can be viewed on our hardware.

**Would benefits of EMD over ADRG merit adoption of EMD as an Army map background standard?** The main benefit of EMD over a compressed ADRG is the decluttering capability. That capability is very limited. On 1:50,000 scale images, the road fill color and the contour lines are the same color. If you eliminate the contour lines, you lose road information. On 1:250,000 scale images, the blue for rivers and lakes is also used in grid lines. The only color layers which can cleanly be decluttered is the purple for aeronautical information and the gray for shaded relief. In its current prototype, EMD does not merit adoption as an Army standard.

## Application Software

**What are the most and least important features of this software?**  
The most important features of this software is the ability to do terrain analysis tasks over a map background. The elevation tracker is useful. Some of the line of sight functions were difficult to use.

**Describe other functions which you require in an operational environment.** Our requirements for operational system are contained in a memorandum to PEO-CCS signed by MG Knudson, SUBJECT: ATCCS Map Background and Terrain Analysis Requirements, 6 June 1990. A copy of this memo should be on file at DCAC, ETL.

## Recommendations

Since EMD is only an interim solution until such time as Tactical Terrain Data (TTD) is available and the EMD provides too limited of functionality, we recommend that the EMD effort be discontinued. If EMD could be produced as feature separates, it may be more useful. However, since this is only a partial solution, it may not be worth the resources.

**DEVELOPMENTAL SCIENCES CORPORATION**



## EMD AND UMEDS PROTOTYPE EVALUATION

### 1. EXECUTIVE SUMMARY

Map prototypes were evaluated for use in manned and unmanned aircraft systems. The systems evaluated were:

- a. UMEDS TTD/ITD
- b. EMD
- c. Past experience with video disk systems

The evaluation is complicated by the sensitivity of the mapping data to the different mission phases. EMD is an excellent approach for the in-flight management and adequate for the mission planning and post flight analysis. It seems simple, fast, and easy to implement and integrate.

Vector data has much greater potential especially in the mission planning and post flight analysis phases since so much more intel data is available. The greatest weakness is in the area of value added and integration of the mapping data with associated data bases and message catalogs. Because of the unexplored potential of UMEDS TTD/ITD, it is much more difficult to evaluate.

We would recommend that the EMD black layer be subdivided. The UMEDS indices supplement of TTD/ITD does not seem to be an advantage to our application but this may be more an artifact of lack of familiarity with the data bases and their application than a real conclusion.

### 2. EVALUATION TEST BED ENVIRONMENT

#### 2.1 Organization and Project Name

Developmental Sciences Corp.  
Unmanned Air Vehicle - Short Range (UAV-SR)

#### 2.2 Point of Contact

Developmental Sciences Corp.  
ATTN: Don Regan  
1930 S. Vineyard Ave.  
Ontario, CA 91761

#### 2.3 Relationship to Government

DSC is a subcontractor for the UAV-SR program. The prime contractor is the McDonnell Douglas Missile System Group. The

Government point of contact is:

MICOM PM-UAV-SR  
Walt Pease  
205-876-1192

#### 2.4 Hardware/Software Used For Evaluation

Computer: New Tech 386  
Weitek 80386/20MHz System Board Version 2  
Intel 80387 DX-20 Coprocessor  
6 Meg Byte Ram Memory  
107 Meg Byte Hard Disk  
NEC Multisync 2A Monitor W/VGA  
Logitech Mouse  
NEC CD-ROM Reader  
DOS 4.0

The above is typical of the PC environment at DSC with the exception of the CD-ROM reader which was added for this project. Other lower end/older machines are also active in the company.

### 3. DESCRIPTION OF TARGET SYSTEM

DSC is active in the area of both manned and unmanned aircraft reconnaissance systems. These systems use map data in several modes:

- a. Preflight mission planning
- b. In flight monitoring
- c. Post flight data reduction

In addition, some DSC customers desire to produce their own maps.

#### 3.1 Stage Of Development

The systems are in various stages of development. Some have been fielded, UAV-SR is in development, and some tasks are IR&D for future systems. In general, geographic system evaluation is a continuing task.

#### 3.2 Target Hardware/Software Configuration

Typical systems, use VME computers with monitors, graphic cards and peripheral tailored for specific requirements. Displays are typically:

- a. Color
- b. 1280 x 1024
- c. 60 Hz non interlaced

- d. Windowed, with the map using between one half and the full view surface

#### 4. EMD EVALUATION

##### 4.1 Format and File Structure Not evaluated

##### 4.2 Data Structure

512 x 512 pixel tiles seem reasonable, 640 x 480 may be slightly more efficient. Fractions of the 512 might allow slightly smaller bit map memories when using look ahead algorithms but the savings are small (<25%).

##### 4.3 Compression Methods Not evaluated

##### 4.4 Utility of Prototype Data Set

###### 4.4.1 Ranking Of Features

Features in order of importance are:

- a. Speed
- b. Minimization of storage requirements
- c. Decluttering
- d. Color normalization

Speed and minimization of storage are of course coupled. Decluttering is almost as important. Color normalization is not very significant and in any case should be treated as a production problem.

###### 4.4.2 Layering

In general the decluttering was valuable. The principle difficulty was in the black layer where the coordinate system was lost when decluttering verbiage. This function could be performed in the software, restoring the grid as an overlay. There may be operator preference in overlay ordering but the ordering effects seem minor.

##### 4.5 Resolution

Resolution at 250 lines/inch was marginal. Some of the smaller text on the TLM Gie Ben map measured .75mm which gives 7.5 lines at 250 lines/inch. We used a color scanner and printer to compare results, unfortunately the scanner did not scan at 250 lines/inch but at 300 lines/inch. This gives 9 line per character and the readability seems increased. In general the scanned data seemed better than the EMD data base but no calibrated study was performed. It would be interesting to know if the EMD data base was calibrated and

quality controlled.

#### 4.5.1 Zoom

The 2:1 and 1:2 zooms seemed usable while the 4:1 and 1:4 did not. The resolution loss at 2X does not seem an issue since only the smallest type is lost. The 4:1 and 1:4 do not seem necessary since a reasonable 2:1 progression can be achieved using 50,000:1 TML, 250000:1 JOG and 1,000,000 DCW/ONC.

#### 4.6 Media

CD-ROM is an excellent distribution media.

In use we would expect to transfer it to hard disk to increase speed and area coverage. Current costs of large 1.2 GByte and larger hard disks make this very feasible.

#### 4.7 Application

The EMD data seems best for the in-flight mode where the aircraft position and sensor foot print are overlaid on the map for orientation and navigation.

EMD data would be used in parallel with DTED data and having it on the same media would be convenient. Vector data and associated data bases are different enough that they should be treated/distributed separately. There did not appear to be any advantage to combining EMD and vector data. If we were going to use vector data we would probably use an entire vector data system.

#### 4.8 Map Background Issues

We have not used ADRG. The advantage of EMD over compressed ADRG is the decluttering which is of great significance.

#### 4.9 Application Software

The features we require are:

- a. Zoom. 2:1, 1:2 and 1:1 are adequate if a full range of maps are available. Continuous zoom is slightly better and should include hysteresis when switching maps.
- b. Pan. Continuous pan should be available. Continuous should be demonstrated since it is a major difference from video disk map systems.

- c. Rotation. It is often desired that aircraft heading be in a constant direction (usually up), and the map rotate and pan under the aircraft symbol in continuous motion. This can be done with EMD but not with video disk or ADRG. It requires label/name declutter and reconstruction of the grid. There is a problem with man made objects, which are also on the black layer.
- d. Lat/Long. continuous lat/long of the map center on the top bar would be an advantage.
- e. Using the mouse in the drag mode is a disadvantage since operational systems often use joysticks or track balls where drag is inconvenient.
- f. 3D isometric type displays or DETD based shading are of great value since many people have difficulty with contour lines.

#### 4.10 Recommendations

The only problem seems to be the use of one separate for several classes. This seems to be particularly noticeable in the black where grid, labels, roads, and man made features are all on the one separate. It might pay to go to 8 bits and separate these features for declutter.

#### 4.11 Evaluation Documentation and Support

Documentation is almost completely open ended, you get what you pay for. The existing documentation was adequate for our evaluation but not particularly easy to use.

It might pay to make a video tape of the capabilities of EMD and competing products. It might also pay to include a system test utility to verify that the system will perform on the hardware as set up. An automatic walk through demonstration of the "press when ready" style might also be a good introduction.

#### 5. UMEDS EVALUATION

The UMEDS evaluation was very difficult since we use the data very differently than USAETL does. USATEL is interested in cross correlating multiple static map features to derive tactical conclusions over relatively small areas of the battlefield. DSC flies reconnaissance aircraft and has the following emphasis.

- a. larger areas
- b. value added data
- c. dynamic features

Modern sensors, including millimeter wave radar, multi spectral cameras, and FLIR at low, unmanned altitudes and in poorly mapped low intensity conflict areas provides unprecedented opportunity for map update and value adding.

The advantage DSC sees in vector data is that it is much easier to modify than raster or video disk data, and the finer attribute structure allows integration of the detailed data being obtained.

## 5.1 Use of ITD/TTD data

### 5.1.1 Mission Planning

Mission planning has three aspects:

- a. Capabilities
- b. Threat
- c. Targets

Capabilities relate to the line-of-sight and uses DTED data. Threat is, in principle, altitude related and also uses DTED data. Targeting is the principle use of vector data. The correlation programs developed by USAETL are excellent for locating potential high importance reconnaissance sites. DSC in this areas sees itself as a user of completed systems or a receiver of target data from other commands. In this respect integrated map data/message catalogs related to the underlying data base are required for data transmission and integration.

### 5.1.2 In-Flight

The map data is used in-flight for orientation for the aircraft and location of reconnaissance targets. For this purpose only a minimum of vector data is required. The major advantage of vector data is the ability to declutter and decimate the data to increase speed and remove distraction.

### 5.1.3 Post Flight

Post flight sensor data is available for data base update and value adding. The major problem here is to do more good than damage to the data base.

## 5.2 TTD Themes

As stated above, when used with DETD data only major visual features are of interest for navigation and targeting. Both ITD and TTD are more than adequate. The detailed themes are of interest because of the ability to update them and for value adding.

## 5.3 Data Structure Issues

In general, we would expect that a preprocessor setting up indices for our specific requirements would be more efficient. The computation time required would not seem to be detrimental since typically the systems have high peak computational requirements and large under utilized periods.

**JET PROPULSION LABORATORY**



**EMD PROTOTYPE EVALUATION  
EUCCOM COMMAND CENTER PROJECT (ECCP)  
JET PROPULSION LABORATORY / CALTECH**

**1. Summarize Evaluation Effort**

The evaluation effort consisted of three parts: 1) Utilizing the supplied EMD Demonstration software on the PC to view and evaluate the EMD product (and User Interface); 2) Comparison of the EMD product with the ADRG-C prototype product; and 3) Comparison of the EMD product with the JPL Neural Network -produced Color Separates product, which produces a map background display similar to EMD from 24-bit ADRG (and 24-bit scanned paper map) products. Results of the evaluation suggest that the EMD product is very satisfactory, providing a significant improvement and utility/capability above that of the standard ADRG product and prototype ADRG-Compressed product (i.e.; reduced data storage and display time plus the option of declutterability and user-selectable colors). The scanned printer map separates EMD product, and the Neural Network map background Color Separates product, were also found to be exceptionally similar, suggesting the potential for an alternative EMD production method for situations where printer separates are not available. Considering that the ADRG-C prototype provides an 8-to-1 data compression factor with Run-Length Encoding (RLE), and the EMD/Neural Network approach produces 14-to-1 compression with Huffman Run-Length Encoding, the EMD approach emerges as a clear winner relative to the ADRG-C concept. Furthermore, the inherent 3-bit EMD display will appear the same regardless of whether the display equipment is 4, 6, 8, or 24-bits, unlike the ADRG-C product which begins to degrade on 4 and 6-bit monitors.

To permit further evaluation of the Neural Network EMD-equivalent product, a 360K IBM/PC diskette accompanies this evaluation that contains the Neural Network equivalent of one EMD 512x512 tile. The data is provided as seven 1-bit files in standard TIFF format that the ETL contractor (SAIC) should be able to read and display with their EMD Demonstration Program software. The result of this effort would demonstrate the similarity and capability of the Neural Network product to produce EMD-like products.

## **2. Identify Organization and Project/Program Name**

PM/AWIS (Program Management/ Army WWMCCS Information System)  
UCCS (USCINCEUR Command Center System)  
HQEUCOM (Headquarters, European COMmand)  
ECCP (EUCOM Command Center Project -JPL)  
EDSS (EUCOM Decision Support System)  
MBS/Map Graphics (Management Briefing System)  
Jet Propulsion Laboratory / CALTECH

## **3. Specify Point-of-Contact and Address**

PM/AWIS: Mr. John Minken  
Ft. Monmouth, NJ  
EUCOM: Lt. Col. George King  
Pach Barracks, Stuttgart, Germany  
ECCP: Dr. Thomas L. Logan (Map Graphics Engineer)  
Dr. Lynn Gref (JPL Project Manager)  
Jet Propulsion Laboratory/CALTECH  
4800 Oak Grove Drive, Pasadena, CA 91109  
818-354-4032

## **4. If Contractor, Describe Relationship to Sponsor**

The Jet Propulsion Laboratory (JPL) is a non-profit research and development laboratory administered by the California Institute of Technology (CALTECH) under contract to the National Aeronautics and Space Administration (NASA). JPL's EUCOM Command Center Project (ECCP) is funded by the U.S. Army, PM/AWIS, to upgrade the command center facilities located at Headquarters, European COMmand (HQEUCOM), Pach Barracks, Stuttgart, Germany.

## **5. Describe Hardware/Software used for EMD Prototype Evaluation**

The ETL/SAIC supplied EMD Demonstration Program software was evaluated on an IBM/PC AT (286 CPU) with 2MB memory, 30MB hard disk, IBM/EGA graphics board and monitor, and a Toshiba XM-5100A CD-ROM player. The Neural Network software was developed on a DEC VAX computer written in C language, and subsequently converted to operate on Apple Macintosh computers, ULTRIX-based DEC computers, and any computer operational with the EXPRESS parallel software with or without transputer boards. The ADRG-C

data was evaluated on DEC VAX equipment using image processing software developed at JPL for the enhancement of NASA space exploration mission imagery.

## **6. Data Structure**

The issue of tile size has been encountered by the DCW prototype, ADRG product, ADRG-C prototype, and now the EMD prototype. In general, the optimal tile size appears to be between 128 and 512 squared pixels. Below 128, display time increases because many tiles must be read and displayed to fill a screen. Above 512, fewer tiles must be read, but the tiles must be partitioned to locate only those portions that are displayable on the given monitor. The optimal tile size is therefore dependent upon the average size display screen expected of the typical user. A 256x256 tile is probably the optimal size, but 128 and 512 tile sizes appear to be quite adequate.

## **7. Compression Methods**

Image compression tests at JPL have determined that the standard Run-Length Encoding (RLE) algorithm is not very efficient, but the Huffman variant of RLE is very efficient. (It is not clear which RLE variant is being used for EMD.) For comparison purposes, the 3-bit (7 color) neural network-produced file (EMD equivalent) actually increased in size to 129% with RLE, but compressed to 20% of the original size with Huffman encoding. On the Macintosh, the file compressed to 16% of the original size using Kodak's JPEG routine, and 49% using the STUFFIT Limbel-Zel approach.

## **8. Utility of Prototype Data Set**

A. The EMD prototype is very usable despite the problems of map feature (layer) overprint (which produces "gaps"), and the map-specific need to display up to two layers in order to compensate for (the few) map features that do not appear entirely on one map separate. Given that the user understands the basis of the EMD product, the stated concerns can be easily compensated for by the user, and do not represent a significant problem. The importance of particular map layers can not be prioritized because their importance depends upon the particular user situation. Any given layer assumes paramount importance given a specific situation, although the least useful layer appears to be Shaded Relief.

B. The relative ranking of Declutterability versus Color normalization versus Storage space is simple: The wider field of view (provided by compressed storage space) is most important. For example, DMA's videodisc product remains viable despite its relatively poor quality analog display because of its large areal coverage. One videodisc provides coverage for a very large geographic area (field of operation), which is critically important when briefing slide preparation time is short (the usual situation). The next consideration is Declutterability since this feature significantly enhances the readability and comprehension of the desired data. The least significant factor is Color Normalization---while improving display comprehension---it is easily understood and compensated for by the user.

C. In operational use, EMD data is intended to be transferred to a hard disk that is accessible via a Local Area Network (LAN) by the users (for improved data transfer speed). Transfer of standard ADRG data would require much more reformatting/transformation than the EMD product because of the ADRG's inherent 24-bit data representation which must be reduced to match other standard DMA map products. Reformatting of the EMD product is expected to be minimal, except where it becomes necessary to merge the data with other DMA map data (e.g., Videodisc; World Vector Shoreline) to produce a large area of interest that is not entirely available from one map product. The need to reformat EMD data will largely depend upon its compressed storage factor cost (on hard disk) versus the direct CD-ROM read time cost. While hard disk storage cost has decreased significantly over the past several years, it is still expensive to provide large on-line geographic areal coverage.

D. The display ordering of EMD layers is not an issue. The resultant composite display is the important factor, and the order in which the layers are displayed is not significant for the EUCOM sponsor.

E. The default layer colors and patterns are sufficient for map background display because they correspond to the original paper map colors/patterns with which the users are familiar. Maintaining direct correspondence between paper map products and the electronic EMD display is important, because it reduces potential confusion that could reduce user efficiency in a crisis situation. The

provided "Layers" menu option is very nice and functional, but would probably not be used very much by the HQEUCOM sponsor.

F. No benefit can be presumed by combining specific map layers, as this assumes a pre-defined mission for the EMD product. There is already too much inherent color/layer combination in paper maps, which increases as map scales decrease (e.g., blue river names combined with the rivers layer; red road numbers combined with the roads layer).

G. The EMD prototype is very satisfactory as-is with the exception of the Shaded Relief layer, which does not display very well, and does not add a significant informational component.

## 10. Resolution

The EMD's 100 micron (254 dots per inch) resolution matches the ADRG (and ADRG-C) resolution and provides a highly satisfactory product. Zooming out by 2X still provides a satisfactory product suggesting (as with the ADRG product) that 127 dots per inch resolution is probably adequate, and the resulting ~~4X~~ reduction in storage and display time is worth the minimal loss in sharpness and detail.

## 11. Media

The CD-ROM is an acceptable media for distribution of EMD data given the current state of technology. There are faster and/or more efficient storage technologies, but none are clearly superior, and those with advantages tend to be proprietary. CD-ROM data transfer speeds are known to be slow, and represent a limiting factor in the use of ADRG and similar products (ADRG-C; EMD). Realtime user requirements will have to accept the slow CD-ROM access time. Non-realtime applications (which constitute the majority of HQEUCOM requirements) permit the transfer of CD-ROM data to hard disk, where map background display times become satisfactory.

## 12. Applications

For the HQEUCOM Command Center Project, the primary use of the EMD product is the same as for the other DMA standard map products: Preparation of a suitable map background to facilitate the conveyance of desired foreground briefing slide information. The

addition of ITD and/or DTED data is very beneficial and highly recommended as it enhances the potential of supplied data access/display software to provide an additional dimensionality (including tactical requirements).

There is no stated "night environment" requirement for the ECCP task.

### **13. Map Background Issues**

Software has been provided to HQEUCOM which accesses and displays standard ADRG map background data files. The user selects 24-bit or 8-bit representation for map background display. Four and Six-bit ADRG-Compressed displays are not adequate because of their poor color representation, and are not supported by system-wide ECCP design (only 8 and 24-bit displays are supported). Given that 4 and 6-bit displays are unsatisfactory, the ADRG-C product provides few advantages over the EMD product. EMD has better compression, correspondingly faster display times, greater areal coverage per CD-ROM, and equivalent display quality across 4, 6, 8, and 24-bit monitors.

### **14. Applications Software**

The User Interface provided with the EMD prototype is certainly the best I have encountered for IBM/PC-based systems. Its primary functions can be easily implemented without reading the manual, whereas the DCW (ESRI) User Interface, for example, is not as well organized, and can only be used by reading the manual. Of course the EMD prototype is much less complex than the DCW prototype, but the EMD main menu is more logically arranged with functions performed left to right, easily allowing the user to work through the menus to produce a desired display. Selected comments follow:

A. The menu item name "Source Graphic" does not convey its purpose. Perhaps a better name would be "Map Information" or simply "Information."

B. Use of the Layer Editing Window is too slow when the user only wants to turn a specific layer on or off. This should be a specific option (perhaps in the "Move to..." box).

C. It was difficult to view the legend graphics because the scroll bars tended to be very "jumpy" and difficult to use.

D. The "Overview" option brings up a table of specific maps to choose from, then a hard-wired coverage map to select a location from. The stippled pattern in the coverage map made it difficult to locate a specific point inside the box.

E. The Gazetteer did not contain the level of detail expected. Only very large towns were included in the gazetteer.

F. Zoom specification is always relative to 1:1. Perhaps it should be relative to the current zoom factor.

G. When the LOS option is selected, the user should not have to then press the "LOS" button to begin the actual process, the process should already be active.

H. The Range Circle seemed to be more oblong than circular.

## **15. Recommendations and Miscellaneous**

EMD display quality was not as good as anticipated for being derived from the scanning of original printer overlays. The edges of many map features often appeared ragged or fuzzy. Are the original printer overlays ragged? I compared the EMD product to the scanned map backgrounds produced by Martin Marietta for DTSS and ASAS (produced from printer overlays) and found they also lacked some of the expected sharpness. I do not have an explanation for this situation.

Overall, EMD is a superior product to ADRG and the ADRG-Compressed products. It is the proper all purpose successor to the analog Videodisc and digital ADRG products because it 1) Offers larger geographic field views; 2) Requires less storage space; 3) Is declutterable; and 4) Has a relatively fast display time. However, the EMD display is not quite as good as the ADRG and ADRG-C visual displays, and for some purposes, the ADRG-C product could be preferred. If only one of the three prototypes can be chosen for full production and support, EMD would be the choice. If DMA can support production of two prototypes, EMD and ADRG-C would be the choices.

## **16. Evaluation Documentation and Support**

Evaluation documentation and support were satisfactory.

The Jewel box and pamphlet are the most informative and complete that I have seen, but the DCW's simple CD-ROM map design has the artistic edge.

## **LORAL DEFENSE SYSTEMS**



## EMD Prototype Evaluation

Summary: Loral has conducted an evaluation of the Electronic Map Data [EMD] Prototype. Factors included in the evaluation include the potential usefulness of EMD for current applications and improvements which might improve data utility, storage and reduce EMD cost. Loral believes that the EMD effort will provide valuable information concerning future directions for the representation of map data in digital formats.

1. Conducted By: Loral Defense Systems  
Cartographic IRAD program  
[Supports application development for DTSS  
and other systems incorporating similar  
technology]
2. Point of Contact: Ed Quinn  
Loral Defense Systems/Akron  
Department 462/G-3  
1210 Massillon Rd.  
Akron, Ohio 44315-0001  
216-796-3387
3. Relevant Government Programs: DTSS, Special Operations  
Forces/AirCrew Training Systems
4. Hardware Configuration: Compaq 386/25, Dos 4.01  
70 MB Drive, Standard VGA  
We used the EMD evaluation Software  
1 MB of RAM  
Microsoft Mouse  
Hitachi CD-ROM reader
5. Local PC environment description: Most PC's used within our organization are Tandon 286's running at 12 Mhz. Generally they have EGA graphics, 1 MB memory, a 30 MB hard disk, both 5 1/4" and 3 1/2" floppy drives, and a Microsoft compatible mouse.
6. Description of Target System:  
  
A potential target system is the Digital Topographic Support System [DTSS]. DTSS is currently completing Full Scale Engineering Development. System fielding is scheduled for August, 1993. This corresponds to the date map background information will be required. DTSS is currently using DMA videomap data as the source of such data. DTSS includes two MicroVAX II GPX workstations running under VMS. A Parallax Graphics display board is also included with each workstation.
7. Format [No Comments]

## 8. Data Structure

The most significant issue is the use of a 512 x 512 tile size. This tile size is substantially larger than the 128 x 128 tiles we are used to working with for ADRG data. It would seem to result in having to read excessive amounts of data to panel together displays, particularly for EGA/VGA graphics cards [due to the fact that approximately four times as much data as will be displayed would have to be read for most displays in order to integrate map sections together]. Even for high resolution [e.g., 1024 x 1280] systems, 512 x 512 appears to us to be excessively large. In addition, since the tile size is not compatible with ADRG, it means additional software modification would be required if the electronic map data were to be considered as a replacement.

## 9. Compression Methods

The one dimensional encoding technique has been used before by us to store digital data base information. We consider it to be a relatively easy to use compression method.

If studies were done of the statistics of the run-length distribution, it might be possible to optimize the number of bits devoted to run-length definition via adaptive encoding. This would increase the complexity of decoding, however.

Note that if the tile size was smaller [128 x 128] the maximum run-length within one row would fit within 7 bits. In combination with the pixel value [0 or 1] this would fit in 1 byte. This might be used to reduce data storage requirements.

One alternative to run-length encoding is block encoding [e.g., of 4 x 4 image areas]. Vector quantization can be applied to the image blocks and a code word used to represent the index into the block table. With small code lengths applied to the most common blocks, compression can be achieved. Vector quantization has the value that it [through current DMA efforts] should become familiar to users of ADRG data. We doubt, however, that the storage requirements for block encoding would be superior to run-length encoding for EMD utilization.

## 10. Utility

The most immediate use for us of this data is as a source of map background information. The EMD prototype appears to have the capability to serve this purpose, although problems occurred in specific areas which must be resolved.

The most obvious impact of using color rather than feature separates is that map series differences have an impact on what information is in what layer. It was found the presence of the UTM grid lines in the WACO 1:250,000 hydrology layer was somewhat confusing. Some hydrology feature names which overprint hydrology

features are not shown because both the feature name and the feature itself are in the same layer [example - Lake WACO].

In the 1:50,000 scale [Texas] maps, the contours, roads, and urban areas are in the same layer. For selective display of feature data, we often would want this kind of information to be in a different layer. Thus the EMD is deficient in this respect.

In the German 1:250,000 scale JOG map, many contours are unreadable due to poor resolution. The 1:50,000 scale maps in this area have the same problem. Other features sharing this difficulty in this area are hydrology feature names and place names.

The paper maps in this area are quite acceptable, whereas the EMD images are not. We suspect a scanning problem occurred in obtaining these images.

DTSS currently does not allocate storage for map data [video disks are the source of map data]. If storage is required, it must be allocated from existing file space. For this reason, storage considerations are very important.

We consider color normalization to be of less importance than storage. It does enhance the operator's ability to interpret the display.

Decluttering by feature type would be considerably more useful than by color. The separation by color layers has allowed the applications software which USAETL provided to support the use of variable patterns to symbolize the map. We consider this capability to also be useful.

We consider the format of EMD to be appropriate for use of the product.

11. Resolution: The 1:1 resolution images was sufficient for the Texas maps. The 2:1 data was not. As noted above, the 1:1 resolution was not adequate for the German areas.

## 12. Media

CD-ROM is adequate as a distribution media. However, access to the EMD data was very slow. If the current speed is an inherent limitation of the CD-ROM media, the relevant files for a given area would have to be loaded onto a separate media (e.g., hard disk) for operational access.

## 13. Applications

Our intended uses of EMD would be: (1) Map Background [replacing video maps in DTSS and serving as a base layer for overlay of products for other applications] and (2) to serve as a source of data base update information in data base construction. For the

reasons stated above, EMD provides the second capability only to a limited degree as compared to the original maps.

Our normal use of digital data base information involves many of the standard products which are available for an area. Although no one product combination applies everywhere, almost all applications require DTED. We do, however, feel that DMA's plans to complete the coverage of Level I DTED and distribute it on CD-ROM media are adequate.

We have no current requirement to use EMD in a night environment.

#### 14. Map Background Issues

Experience with ADRG: ADRG is one of the specified inputs for the Special Operational Forces Aircrew Training System contract. In this context, we have already received and used ADRG data as a source of map background information. Our usage requires that the data be transformed such that it can be used within an eight bit [or smaller] pixel depth system. We have defined a transformation to a very usable eight bit format [the information on this transformation was previously provided to USAETL]. Subsequently, we have performed experiments designed to further reduce storage via color quantization and mixed pixel analysis.

Currently, our 8-Bit format for ADRG is serving our purposes. It would, however, be very desirable to substantially reduce storage requirements. Six bit or four bit display representations, although useful, have only a limited impact on online storage. Representing the data as layers and coding each via run-length encoding does, therefore, have substantial merit for storage purposes.

The advantage of EMD over ADRG therefore is primarily storage. The disadvantage is the apparent loss of resolution for certain of the maps in the prototype. If this were typical of EMD [and we doubt that it is], it would hinder its acceptance.

#### 15. Applications Software

The most important feature of EMD is the ability to choose an image to be displayed by several methods: by overview, location and scale, source graphic [map] name, gazetteer [place name], or coordinates. This flexibility allows the user to display a chosen image easily, instead of having to rely strictly on knowing the latitude and longitude of a given location.

The point-to-point line-of-sight option in the Other Information menu is also a most important feature. It creates a terrain profile of the Earth's surface between two user-defined points. This ability to quickly plot a profile to determine if one can or can't be seen could be important in a battlefield environment.

The least important feature would be the Quality submenu located

in the Source Graphic submenu. It should only be necessary to list whether or not the map falls within a specified accuracy range instead of providing a long list of information.

The separation of existing layers into additional layers would make map interpretation much easier and would greatly increase the utility of this product. Despite the limiting factor of the color separates, more could be attained through further refinement of the map compilation techniques. As an example, the UTM grid lines are in the same color layer as the water features. The UTM grid is, however, an entity that it is possible to generate mathematically. By doing so, it should be possible to predict the location of the grid in the scanned data and eliminate it, placing the grid in a separate layer.

#### 16. Recommendations

The EMD prototype provides a useful tool to evaluate improved methods of data compression. The obvious drawback is the amount of scanning work to be performed to provide the data.

We believe that it may be possible to generate this type of information either directly [by applying more sophisticated processes to a scan of the color map] or through a combination of a scan of the color map and a [limited] selection of feature separates. Knowledge, for example, gained by scanning a transportation separate might improve the interpretation of the color map by identifying the presence of a portion of the line work. This would reduce the amount of processing necessary to separate features by color [boundary conditions for line objects are among the most difficult to resolve].

Scanning with a 100 micron aperture is not adequate for color separation processing. Too many mixed pixels would be generated which would be difficult to classify. Providing 100 micron data from a higher resolution data set is not, however, difficult. In addition, run-length encoded data is not affected as much by resolution as is raster data [so long as the number of objects does not increase].

#### 16. Evaluation Documents and Support

We felt that DCAC conducted the evaluation in a very professional fashion. The Users Manual, Product Specification and Jewel Box Pamphlet were certainly adequate to support the evaluation.

**HYPERDINE, INC.**

## **EMD PROTOTYPE EVALUATION FINDINGS**

**Prepared by Hyperdyne, Inc.**

*(The findings contained herein are solely those of Hyperdyne, Inc.  
and do not represent the views of any other parties)*

### **Executive Summary**

**Hyperdyne believes that:**

the format proposed for EMD is entirely adequate and that compliance to ADRG is desirable

the data structure is close to optimum, with 1024x1024 tiles being a second choice

consideration should be given to supporting more compression formats than just RLE

complicated layering schemes are not required

EMD data should be exportable to non-EMD-specific software

the scanning resolution was optimum

CD-ROM is the best distribution media

EMD should not be combined with other digital data sets

a compressed ADRG would reduce the requirement for EMD

### **Evaluator Information**

This evaluation was performed by Hyperdyne, Inc., a small business in Annandale, Virginia engaged in development of GIS products and services for government and civilian applications. The project in which we are currently engaged is the customization of our commercial GIS, called "Mapix", for use by the U.S. Army Human Engineering Laboratory at Aberdeen, MD, for their use in support of their on-going research in the areas of Fire Support and Command & Control. The point-of-contact at Hyperdyne is

John Wilson  
Hyperdyne, Inc.  
4004 Woodland Road  
Annandale, VA 22003  
(703)354-7054 (voice)

**The point of contact at USA-HEL is**

U.S. Army Human Engineering Laboratory  
ATTN: SLCHE-FT (D. Tyrol)  
Aberdeen Proving Ground, MD 21005-5001  
(301)278-5890 (voice)

## Evaluation Environment

The EMD prototype was evaluated using an IBM-compatible, 80486-based PC built by Gateway-2000, running at 25 MHz. The system has: 8 MB of RAM; a 300 MB hard disk; a Video-7 VRAM VGA capable of up to 1024x768 16-color graphics; a Logitech mouse; and a SONY model 510 CD-ROM drive.

This PC is not necessarily representative of those on which our users would run software such as EMD-based applications. A minimum configuration we recommend is a 386 with 2 MB of RAM, 100 MB of hard disk, an 800x600 VGA.

## Target System

Hyperdyne's interest in EMD relates to our Mapix product, a raster-based GIS. Mapix is currently available off-the-shelf for MS-DOS/MS-Windows systems. A Unix/X/Motif version will be available in May 1991. Our present and prospective customers indicate delivery requirement ranging from immediate to 6 months hence. See "Evaluation Environment" above for recommended system configuration.

## Format and File Structure

We found the ISO 8211 file format entirely acceptable as a distribution standard. Similarity to the ADRG specification allows re-use of software modules designed for that product. A desirable goal would be to minimize those small differences between EMD and ADRG that are not due to fundamental differences between the two products.

## Data Structure

We found 512x512 tiles acceptable. This size results in acceptable buffering requirements for real-mode PC applications where memory is at a premium. Because of performance considerations, however, we believe that low-end XT-class machines should not be considered a realistic platform to be supported. We have found in our projects that tile sizes which are comparable with or slightly greater than the target screen resolution are optimal. This reduces the typical number of tiles which must be assembled for each screen repaint and reduces the concomitant mass storage seek time penalty (especially severe for CD-ROMs). As "standard" user displays edge toward 800x600 or higher, a 1024x1024 tile size might be more appropriate.

## Compression Method

The run-length encoding employed does a fairly good job of compressing line-art type images such as EMD separates. Decoding is simple and efficient in software. Similar approaches (e.g., RLE, RLC, Scitex formats) have been proven effective in the publishing industry for years.

One suggestion we might offer is including the capability to employ other encoding techniques in future product. The "RL ENCODE" field in the EMD Information Record could be changed to "COMPRESSION" and assigned different code letters for different techniques (e.g., "N" = none, "R" = RLE, "4" = CCITT Group IV, "L" = LZW, etc.). Incorporation of 2D compression would also require some modification of the line index structure (PIXEL/TILE fields) because 2D compression must compress *bands* of lines. Storage requirements are probably the biggest concern for raster-GIS users so more efficient compression techniques (even hardware-based approaches now appearing on the market) may be highly desirable. In particular, 2D approaches, such as CCITT Group IV, work especially well on connected-feature-type images such as map separates. Low-cost, very high speed compression chips on the market would make this a very effective way of both reducing storage requirements, and, given the slow CD-ROM data rates, would enhance performance. Any compression technique employed probably should have software-only implementations, of acceptable efficiency, so as not to preclude use by users without hardware



augmentations.

### Utility of Data Set

We believe that the primary utility of EMD is as a background map to serve as a context in which dynamic overlay data is displayed. As such, implementation of "layering" ala vector-based GISs is of secondary importance. Users who require fully layered cartography will not be satisfied with feature- or color-separate layering. Those who require contextual map backgrounds will probably leave all the layers "on" all the time. We believe that the "window" between these two classes of users is narrow, and possibly not large enough to justify strong weighting in any tradeoff. Along a similar vein, complicated and totally general schemes for prioritization and assignment of color mapping would likewise be a possibly confusing and rarely-used feature except for "gee-whiz" appeal -- we believe most end users would be quite happy just to have the maps rendered as the originals.

Our assessment of priorities vis-a-vis rendering of separates is as follows:

Primary:	Storage Requirements/Performance
Secondary:	Decluttering
	Color Normalization

We believe that, in general, EMD data would be restructured for operational needs. Many users would want to use EMD data outside of EMD-specific applications programs. An example might be preparation of briefing charts with a presentation graphics package or inclusion in documents via desktop publishing. Performance would be another criteria that might warrant reformatting of EMD data in ways tailored to the target system's native characteristics.

Possible candidates for other formats are: Tagged Image File Format (TIFF), CCITT Group IV, PCX, raw RGB, X-Window bitmaps, Microsoft Windows device-independent bitmaps (DIB), and Sun Color Raster (SCR).

### Resolution

The 100 micron scanning resolution seemed perfectly adequate. Higher densities would not significantly improve readability of most text. A somewhat lower density might suffice, however conformance to ADRG densities would be a desirable synergism.

### Media

CD-ROM is probably the most efficient media for distribution because of low-cost, widespread availability, and standardization of formats. For the reasons cited in "Utility of Data Set" above, reformatting of the data would be required in many applications.

### Applications

We intend to use EMD in conjunction with Hyperdyne's raster GIS, Mapix. Mapix's Import capability would be expanded to accommodate EMD. (An ADRG import capability is currently included with the product).

We believe that distribution of EMD separate from other digital products is most appropriate. Combination with other products pre-supposes a user requirement profile and necessarily would involve a tradeoff of capacity. Furthermore, updating and management of multi-format discs would be a complication.

We have no opinion with regards to night use of EMD.

## **Map Background Issues**

Hyperdyne is active in development of ADRG-related software. Support for ADRG in our Mapix product is a requirement in our current Army contract. Mapix currently can import ADRG into PCX format used in most PC-based graphical applications.

We use ADRG in compressed form. Our extraction process compresses raw ADRG data from 24 to 8 bits per pixel and encodes the result using simple run-length compression. Third party packages are used to reduce ADRG to 4-bit dithered images. We have plans to incorporate JPEG compression into Mapix to allow use of this advanced compression technology.

We believe that a reduced compressed form of ADRG would reduce the necessity of EMD. We have insufficient data to estimate the degree.

The advantages we see of EMD vs. ADRG are:

- decreased storage requirements through compression;
- increased quality of display through elimination of most scan artifacts;
- higher-quality output from low- to mid-range color printers.

EMD suffers from the following disadvantages compared with ADRG:

- higher production costs;
- reduced availability of source graphics (requires separates);
- lack of continuous tone capability.

Hyperdyne has no opinion on the relative merit for applications Army-wide. We will support EMD on internal R&D funds if it becomes a standard product.

## **Application Software**

The included evaluation application software proved adequate for the purposes of evaluation. The most important feature was the ability to view and peruse the EMD maps on a widely-available platform. The least important features were pseudo-end-user features such as overlays and mensuration (these are irrelevant to the purpose for which it was designed).

## **Recommendations**

Overall, Hyperdyne recommends that the Army and DMA continue pursuing raster-based map background products. Some of the capabilities of raster-based products are unique and will never be acceptably duplicated with vector-only solutions.

We also firmly believe that it is in the best interests of the Army if any EMD-type products are made as accessible as possible to non-EMD-specific applications. Many Army users use off-the-shelf-commercial products for preparation of briefing, reports, plans and for operational applications. The ability to use EMD for such purposes would widely increase its appeal and usefulness over what might be achieved through a handful of painfully procured EMD-specific applications programs. A useful addition to every EMD volume might be a set of utilities to export the EMD data sets in one or more commercial industry standards such as TIFF, PCX, etc.

**E-SYSTEMS, INC.**

## EXECUTIVE SUMMARY

We are interested in the potential use of EMD in a variety of workstation environments ranging from highend workstations to the new baby Sparc stations and PCs. Our participation in the EMD evaluation will help us to determine the utility of such products. Our long term goal is to move the data to a variety of workstations including the Stardent 2000 series, various Sun workstations and proprietary systems. In such domains we intend to examine the utility of reformatting the data and compressing the data using alternate approaches. Our principal concern is the general utility of EMD designed for use on micros with minimal display capabilities.

## EVALUATION TEST BED ENVIRONMENT

Organization: Mapping Systems; E-Systems, Inc.  
Program Name: Source Preparation Segment, DMA Digital Production System and Map Analysis and Processing System IR&D program  
Relationship to Gov't Sponsor: Source Preparation Segment Contractor For DMA

Testbed facilities include in-house Stardents, Sparc stations, and IBM compatible clones with VGA and/or EGA interfaces. These systems have widely varying memory, disk capacities and cycle times. The PC related portion of the evaluation was performed primarily on a PS2/80 with mouse, CD-ROM reader. A low-end PC environment is not representative of our environment.

## DESCRIPTION OF TARGET SYSTEMS

As commented earlier, the potential target systems cover the range of existing workstations with an emphasis on high end capabilities. Many requirements for map information are known to exist; however, at this time no specific requirement would favor the use of EMD data instead of reprocessed ADRG. The majority of software environments will undoubtedly require the use of Unix, or VMS.

## MAJOR EVALUATION ASPECTS

### Format and File Structure

As written, the proposed EMD prototype specification appears relatively complete in most areas. Our only area of concern lies in the image format portion of the specification. In this area, we feel that additional work may yield higher utility for the EMD product in the field. The framework for this comment is contained in the Data Structure, Compression Method, and Resolution paragraphs to follow.

### Data Structure

The 512 x 512 tiling system used in the EMD data structure appears to be related principally to memory limitations of previous generation micros and convenience due to the current RLE compression technique. If in fact each tile is broken up into subtiles with the subtile size specified on a per tile basis, speed of display would only be weakly effected by the tile size. Such zoning should also favorably effect compression of the separate for storage.

### Compression Methods

The compression method selected appears to leave significant room for improvement. Trade-offs between algorithm complexity, minimum volume, and time to display should be further explored. Techniques to be explored include

- division of tiles into subtiles
- subtile by subtile RLE count word length optimization
- higher complexity RLE encoders (flagged, etc.)
- subtile by subtile huffman encoding
- line-to-line Fax-like encoders and 2-d techniques

It should be remembered for most complex encoding techniques, the resulting compressed volumes are often inversely proportional to the computational time expended to compress the data.

### Utility of Prototype Data Set

The production of the provided EMD data was performed using high standards; however the quality of the data written to the disk can hopefully be improved. The often described need for a decluttering capability appears to result in part from poor image quality produced by the selected thresholding technique. On modern workstations, 32-256 color raster maps appear to have a higher utility than EMD data. Partial to nearly complete decluttering can be accomplished when using various raster maps produced by clustering/vector quantization techniques. The most important criteria which must be applied to raster map representations are:

- quality of representation
- maintenance of required accuracy
- minimization of required disk storage capacity
- minimization of buffer/computer memory required to build and maintain displays
- time to display

and infrequently

- color normalization and decluttering

In high performance environments, any data file will need to be reformatted if the production format hinders high-speed access and display; this will also be true for EMD data. Ideas related to such formats have been expressed in previous paragraphs discussing data structure and compression methods.

### Resolution

For each useful map or map area, we normally have an associated accuracy statement. When such map material is scanned for subsequent storage and use, the scanning process can decrease the accuracy of the map. Grayscale scanning retains line profiles and object placement better than the proposed thresholding approach to be used in the production of EMD data. Multiple producers were referred to in the EMD demo. In most cases, grayscale scanning at

250 lines per inch will retain the nominal accuracy of the data represented on the map separate. However, for the thinnest lines used by some map producers thresholding techniques are expected to increase the nominal placement error and in some cases produce broken lines. At the very least, if separates are scanned at 250 lines/inch using simple thresholding techniques, accuracy statements associated with the resulting data should be modified.

### Media

The choice of the CD-ROM as the media for distributing EMD data may be premature. The cost of purchasing and maintaining mastering facilities may not be well spent with the advent of read/write optical media and new high density tape drives for micros and archives. To ensure the widest possible usage of the product, output to various forms of tape and read/write optical media should be considered as an on-going proposition. The CD-ROM provided as part of the demo was of excellent quality for a prototype product.

### Applications

Most potential applications for raster map data fall into one category, planning. Associated with planning related endeavors is the production of briefing materials including hardcopy, transparencies and direct computer displays. In addition to raster map data, the ability to overprint, overlay, or simultaneously display other handbuilt and database derived information is essential.

Where possible all DMA products covering the same area should be packaged using a single media type constrained only by security considerations.

If EMD in its present form is standardized it should be included with other DMA production within a set of CD-ROM's (or other types of media) representing an area.

### Map Background Issues

ADRG was to provide a basis from which contractors or end users could reprocess raster map data to meet their individual, group, Department, or Agency needs. If a "true color" workstation is available and data storage is not a significant

constraint no further compression of ADRG is required. Standards for compressing color data are still under development. How best to compress such data for each possible color lookup table constraint in use has not been resolved. For most maps so called 5-bit, 6-bit or 8-bit compressed formats are required to produce high quality representations of the data. As a contractor we will use any required data type, but suggest that more work is required to improve the compression technique and quality of the EMD product and for n-bit color compressed background maps.

While working with the EMD evaluation software it was noted that if people were even interested in a subset of the layers provided, only a few were normally selected. To enhance the types of display produced, copies of selected layers might be stored with a greater dynamic range for uses where that layer is combined with only one or two additional layers or used alone for reference.

#### **Applications Software**

The differences between PC grade equipment and workstations is blurring rapidly. The utility of applications software provided to assist with the EMD evaluation would be enhanced if cast in the Unix, X-windows, Motif environment. A reasonable goal would be to cast each class of operational capability as a toolkit or toolkit element compatible with evolving standards in these areas.

The software provided easily fulfilled the requirements of the evaluation. For future development, commercial toolkits and packages should be emphasized. The GUI provided for use in the evaluation seems to provide only minimal functionality and was at times cumbersome. (e.g., sliders used with windows and browser functions need significant work when compared to the Mac GUI or the Windows interface.)

#### **Recommendations**

We believe that significant advantage may accrue to the utility of EMD as a product if additional work is performed to improve the compression technique currently under consideration. We also believe that a variety of background map types will find utility in evolving workstation environments. Due to the high cost of



scanning separates to produce EMD, we also feel that the separates should be scanned and retained as grayscale data. After scanning, a more controlled quality driven interactive process can be used to threshold the scanned data for EMD use. The initial scanning resolution should correspond to that required by DMA for purposes of vectorization and if necessary reprocessed to a lower resolution for use as EMD. Retention of the grayscale data can subsequently reduce the cost of producing vector representations from cartographic materials.

Standardization of raster map data based primarily on low level PC constraints may inadvertently reduce the capabilities available of higher level systems. Where possible a family of formats and processing techniques should be sought to provide high quality displays on highend workstations and comparable displays in PC environments. Before standardization of an EMD format takes place work to improve the quality of the proposed product appears required. The legibility of annotation and the quality of line representations need improvement at full resolution.

#### Evaluation Documentation and Support

The documentation and support provided as part of the EMD evaluation have been excellent. (No further elaboration is necessary.)

13 December 1990

## EMD PROTOTYPE EVALUATION

## 1) BACKGROUND

This Electronic Map Data (EMD) Prototype evaluation effort is designed to further define the Army's requirement for a digital map background product. Army has stated that the currently available map background product, Defense Mapping Agency's (DMA) Arc Digitized Raster Graphics (ADRG), does not fully satisfy Army's requirements. A survey conducted in 1st quarter FY88 demonstrated a strong need for a product which would require minimal storage, support decluttering, and normalize color across map sheets. A formal statement of this requirement was prepared by the Office of the Deputy Chief of Staff for Intelligence (ODCSINT), who also proposed a prototype development effort based upon this requirement statement.

The EMD Prototype was developed to meet the Army's stated requirements, and, as nearly as possible, to be compatible with the specifications for DMA's ADRG. In a separate effort, DMA is investigating the possibility of providing ADRG in a compressed form. It is necessary to determine whether or not a compressed ADRG would meet essential Army requirements, or whether a standard based on an EMD-like product is merited. The U.S. Army Engineer Topographic Laboratories (USAETL) intends to prepare a map background requirements statement and a revised (if necessary) product specification based upon user response to this evaluation.

## 2) EVALUATION REPORT GUIDELINES

## EXECUTIVE SUMMARY

Summarize Evaluation Effort

## EVALUATION TEST BED ENVIRONMENT

Identify Organization and Project/Program NameSpecify Point-of-Contact and AddressIf Contractor, Describe Relationship to Government  
Sponsor/ProgramDescribe Hardware/Software used for EMD Prototype Evaluation

Type of IBM PC or Compatible Computer (example: Zenith 248,  
Compaq 286/386, etc.)  
DOS Version

Describe Hardware/Software used for EMD Prototype Evaluation  
(Cont.)

Hard disk size (40 Megabytes, etc.)  
Size of RAM (Kilobytes or Megabytes). Minimum 640K  
required.  
Type of Monitor (EGA or VGA)  
Resolution of Monitor  
Type of Mouse (Logitech or Microsoft)  
Type of CD-ROM reader

The EMD prototype was developed for a low-end PC environment with minimum hard disk and RAM requirements. Is this representative of the PC environment within your organization? If no, please describe.

**DESCRIPTION OF TARGET SYSTEM(S)**

If applicable, please specify as follows:

Describe Stage of Development

Identify System Fielding Date

Indicate Probable Date for Needing EMD or Similar Digital Map  
Background Product

Describe Hardware/Software Configuration of Target System(s)

**MAJOR EVALUATION ASPECTS**

Format and File Structure

Review the EMD prototype product specification and provide comments and recommendations pertaining to the prototype format and file structure. Describe any alternate format and/or file structures that could improve access time, further minimize storage requirements, and/or provide a better structure for developing future application software.

ISO 8211 is normally used as a transfer standard, however, it may serve as a distribution format. Was ISO 8211 utilized to its fullest potential within the EMD prototype? Should something other than ISO 8211 be used? If yes, please describe and justify.

Provide any additional concerns or comments relating to EMD format and file structure that were not addressed above.

### Data Structure

EMD images are built using 512 pixel by 512 pixel tiles. Do you have a need for a different tile size? If yes, please describe the required size. Keep in mind that tile size affects the speed of display.

Provide any additional concerns or comments relating to the EMD data structure that were not addressed above.

### Compression Methods

The EMD Prototype uses a one-dimensional run-length encoding technique. Are there additional compression methods or other run-length encoding techniques that you feel are better for a product such as EMD?

### Utility of Prototype Data Set

Map features often overlap, or overprint, one another (e.g., roads cutting through cities, names on vegetated areas, etc.). This has implications for a digital product based upon the individual color separates. For example, when showing only the vegetation overlay, it is possible that a "gap", corresponding to the position of a road, will be present. In addition, because only one color is shown for each pixel location, the ordering of the layers on the display monitor may be important (e.g., if the transportation network is most important to your application, it would be most reasonable to display the transportation file last, or "on top" of the other layers displayed).

Another characteristic of color separates is that not all features appear entirely on one separate. The principal example is that of highways and improved roads, which are comprised of a brown fill and black casing. The result is that both the black and brown files must be displayed to completely depict all roads.

Please comment on the impact of the EMD characteristics stated above. Indicate whether these phenomena make the data set unusable, or describe how you compensated for these effects. Also comment on which layers you typically found most important.

Rank in order of importance, your requirement for each of the following: a) decluttering by color separates, b) color normalization across map sheets, and c) minimization of storage requirements.

In your routine operations, would the EMD need to be transformed (reformatted or restructured) for a particular system? If yes, describe the system and required format.

### Utility of Prototype Data Set (Cont.)

EMD provides the capability to display the layers in any order. Which order most fits your application?

Describe the layer color and pattern assignments that were most useful.

Could certain layers be combined and still meet your requirements? Describe why or why not and which layers.

Provide any additional concerns or comments relating to the utility of the prototype that were not addressed above.

### Resolution

The EMD Prototype was scanned at a 100 micron resolution. Displaying an EMD image at 1:1 depicts this resolution. Is this sufficient for your requirements? For example: Was all text legible, how did it compare to the paper maps, etc? By zooming out 2x, this display represents an equivalent scanning resolution of 200 microns. Is this resolution sufficient? Please discuss.

### Media

Is the CD-POM acceptable for distribution of the EMD?

In normal operations, would you anticipate EMD be loaded onto another media type (i.e., hard disk)? If yes, please describe media type and reason(s) for transferring to this media.

### Applications

Describe intended uses of EMD or similar digital map background product.

Would you prefer to see EMD distributed by itself or combined with other products (e.g., ITD, DTED, etc.) on the same distribution media? Please describe which products.

Is there a requirement to use EMD in a night environment? If yes, please describe.

### Map Background Issues

Many evaluators have experience with DMA's Arc Digitized Raster Graphics (ADRG). If applicable, please address the following questions to the best of your knowledge.

Describe briefly your experience with or knowledge of ADRG.

### Map Background Issues (Cont.)

Are you currently using ADRG or a compressed form of ADRG? If yes, describe application and any transformations performed.

If a compressed form of ADRG (4, 6, or 8-bit) were available, would you still have a requirement for EMD? If so, describe the advantages and disadvantages of each product as it applies to your map background requirement(s).

Would benefits of EMD over ADRG merit adoption of EMD as an Army map background standard? If so, would you be interested in funding production of EMD?

### Applications Software

The application software provided with this prototype is only intended to assist in the evaluation. However, any comments on the software will assist DCAC in evaluating other comments and help improve future efforts.

What are the most and least important features of this software?

Describe other functions, not included in the prototype applications software, which you would require in an operational environment.

### Recommendations

Please provide recommendations for Army and DMA regarding the future course of EMD or similar digital map background product. Also provide any additional recommendations concerning evaluation topics addressed above.

### Evaluation Documentation and Support

Please provide comments on the evaluation guidelines and support you received from DCAC personnel as part of this evaluation. This information is necessary for future prototypes and evaluations to be successful.

Provide comments on the EMD Users Manual, EMD Prototype Product Specification and Jewel Box Pamphlet. Were they adequate for you to complete the evaluation?

## BIBLIOGRAPHY OF KEY EVALUATION DOCUMENTATION

1. Prototype Product Specifications For Electronic Map Data (EMD), Final Draft, 1 October 1990
2. Electronic Map Data Application Software User's Manual, November 1990
3. EMD Prototype Evaluation Guidelines
4. EMD Prototype Jewel Box Pamphlet
5. Maps